Dirasat, Agricultural Sciences, Volume **33**, No. **2**, 2006

Efficiency of Microbial Phytase on the Phytate-phosphorus Utilization by Broiler from 3 to 7 Weeks of Age

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ABSTRACT

The effect of dietary phytase on phytate– P availability was investigated using 800 unsexed Lohman broiler chickens, from 21 to 49 days of age, were assigned randomly to 4 treatments (4 replicates/ 50 chickens/ treatment). Diets were formulated to contain 3 non-phytate P (NPP; 0.368%, 0.262% and 0.128% in diet) and 3 levels of phytase (0, 200 and 400 U phytase/ kg diet). The 4 dietary treatments were: control (NPP=0.368%, NRC, 1994); T1, (NPP= 0.262% + 200 UP/ kg); T2, (NPP= 0.262% + 400 UP/ kg) and T3, (NPP= 0.128% + 400 UP/ kg). Blood, bone, meat from breast and thigh and liver samples were collected for further analysis.

At 49 days old, a significantly ($P<0.05$) higher final body weight and lower Feed Conversion Ratio (FCR) were found in chickens from the T1 and T2 groups compared with chicken from the control and T3. Calcium (Ca) concentration in blood serum and Ca% in drumstick and thigh bones were significantly ($P<0.001$) higher in chickens in T1 and T2 compared with the control and T3. Phosphorus percentage in drumstick bones was significantly ($p<0.05$) higher in T1 and T3 compared with the control and T2, but in thigh bones it was significantly higher in T2 compared with the control and T3. A significantly higher percentage of crude protein ($P<0.001$) and lower crude fat ($P<0.05$) in breast and thigh meat were detected in T1 and T2 compared with the other two groups. Moreover, bone strength (kg force) of drumstick and thigh were significantly ($P< 0.05$) improved by adding phytase enzyme with 0.262% of NPP in diet.

In conclusion, this data suggested that adding phytase to broiler finisher diet improved the general performance and meat quality especially when NPP was reduced by 28.8% of the recommended level by NRC.

KEYWORDS: Phytase, Broiler, Finisher, Phytate and Bone.

1. INTRODUCTION

Phosphorus is the most important mineral for bone mineralization, immunity, fertility and growth of all farm animals. Poultry and swine utilize only 30- 40% of the phosphorus found in feedstuffs of plant origin, with a reminder being as a Phytate form which is inaccessible. Because of that, adding inorganic phosphorus to monogastric animal rations is widely used to cover their requirements. Most of the Phytate- P is excreted in the feces, which can cause an environmental pollution. Kies et al. (2001) reported that about 70 to 80% of P in feedstuff of plant origin present as phytate and birds are unable to hydrolyze it because of lack of specialized enzyme. Nowadays, using microbial phytase enzyme is widely used to break down Phytate and liberate more phosphorus for use by birds and possibly correct the environmental problems. Theoretically, the amount of P present in feedstuffs as phytate can be sufficient to meet the P requirements of poultry, but requires the addition of phytase enzyme to cleave the ortho-phosphate group from phytate molecule (Nelson et al., 1971). The efficiency of adding microbial phytase to release phytate- P has been reported by several researchers (Simons et al., 1990; Mitchel and Edward, 1996; Sohail and Ronald, 1997). The response of broiler to the addition of phytase mainly influenced by the doses used and the level of dietary Non-Phytate- P (NPP). Denbow et al. (1995) reported that Phytase improved body weight gain and feed intake of broiler (0 to 3 wks old) at all dietary NPP level, but the response was greater at low NPP levels.

Most of the reported studies were conducted during

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Table 1. The ingredients and the calculated chemical analysis of the experimental rations (Finisher).

Ingredients	C	T1	T2	T3
Corn	673	674	674	680
SBM	291	290	290	289
Palm Oil	9.0	7.1	7.1	4.8
DCP[a]	10.9	6.1	6.1	0.0
Limestone	15.2	17.7	17.7	20.8
D- L Methionine	0.80	0.80	0.80	0.80
D- L Lysine	0.80	0.80	0.80	0.80
Vit. & Min. premix [b]	1.0	1.0	1.0	1.0
Salt	3.0	3.0	3.0	3.0
Phytase U/ Kg feed	0.0	200	400	400
Total (Kg)	1000	1000	1000	1000
Calculated chemical analysis (As fed):				
ME Kcal/kg	3054	3038	3038	3035
CP%	19.9	19.9	19.9	19.9
ME/CP%	153	152.7	152.7	152.3
Total Ca%	0.853	0.860	0.860	0.888
Total P%	0.608	0.506	0.506	0.378
NPP[c]%	0.368	0.262	0.262	0.128
PP[d]%	0.240	0.244	0.244	0.249
Methionine %	1.101	1.101	1.101	1.101
Lysine %	1.757	1.755	1.755	1.754

[a] DCP= Dicalcium phosphate
[b] Every 1 gram of premix contained: vitamin A= 1500 IU; Vit. D3= 150; Vit. E= 200 ug; Vit. B1= 200 ug; vit. B2= 200 ug; vit. B6= 300ug; vit. B12= 0.5 ug; vit. K3= 200 ug; Folic acid= 30 ug; Panth. Acid = 550 ug and Nicotinamide = 1 mg. Minerals: Fe_2SO4= 550 ug: Mn2SO4= 450 ug; Zn_2SO4= 230 ug; Cu_2SO4= 56 ug Ca2CO3= 14 ug.
[c] Non Phytate Phosporus.
[d] Phytate Phosphorus.

starter or starter and finisher period. Few studies investigate the efficiency of using phytase during 3 to 7 wks old. Because of that, this study was conducted to determine the effect of adding microbial phytase to the finisher diet of broiler (from 3 to 7 wks of age) fed corn-SBM ration with different levels of dietary Non- Phytate - Phosphorus (NPP).

2. MATERIALS AND METHODS

Eight hundreds, 21 days old with an average weight of 643+9.5 g, unsexed Lohman broiler chicks were used in this study for 49 days to investigate the effect of supplementing microbial phytase to finisher diet of corn-soybean for broiler to study the utilization of Phytate- P. Chicks were divided into four treatments of four replicates, fifty chicks in each replicate and separate pen. Chicks reared in concrete floor pens (2.5X2.5 m), which were covered with approximately 7-cm wood shaving. Diets and water were provided for ad-libitum consumption. The dietary rations were formulated according to NRC (1994) to have the same nutritive values, isocaloric and isonitrogenous, except for available phosphorus P (Table 1). Different levels of Non-Phytate Phosphorus (NPP) were achieved by adding different levels of Dicalcium Phosphate (DCP) as shown in table (1). The treatments are as follows: C, control group corn-soybean diet (1.09% DCP for finisher diet); T1, ration 1. (0.61% DCP) + 200 U phytase/ kg diet; T2, ration 1 (0.61% DCP) + 400U phytase/ kg phytase; T3, (0%DCP) + 400 U phytase/ kg diet. The different levels of DCP were used assuming the phytate- P availability will be increased and cover the chick's requirements as a result of adding microbial phytase. The phytase enzyme was NOVO® CT from Novo Nordisk, Denmark. All the chicks in the experiment were fed the same starter diets for the first 21 days and the finisher diet for 28 days. Chicks were kept under the same environmental conditions and were vaccinated against common diseases. Bodyweight (g) was recorded at 21, 35 and 49 days old. Blood samples were collected at 21, 35 and 49 days. Blood serum was collected by centrifugation (3000 rpm/ 15 minutes). Blood serum was analyzed for phosphorus calorimetrically (AOAC, 1990) and calcium concentration by atomic absorption spectrophotometer. Bone breaking strength of thigh and drumstick were measured by new testing instrument developed by the Faculty of Engineering.

The total feed intake for the period of 28 days was reported for each pen. Average bodyweight gain (g) and feed conversion (g feed/ g body gain) were calculated. At slaughter, meat samples from breast, thigh and drumstick were taken beside liver samples. Thigh bone samples were collected from 4 chicks/ each replicate, dried in oven at 105ºC over night, burned in the muffle furnace (600ºC/ 6 hrs) and ash% was calculated on a dry matter basis (AOAC, 1990). Liver, breast and thigh meat samples were prepared and analyzed for crude protein and fat according to AOAC (1990).

3. STATISTICAL ANALYSIS

Data of this experiment were subjected to ANOVA using the general linear model of SPSS® version 11.0. The main effect of adding phytase enzyme on the performance of broiler chicken compare to the control group (adequate NPP and calcium, NRC (1994)). Treatment means were compared using protected Least Significant Difference (LSD) of SPSS®.

4. RESULTS AND DISCUSSION

Broiler Chickens Performance

The effect of dietary supplementation of phytase on Body Weight (BW) at 21, 35 and 49, and accumulated Feed Conversion Ratio (FCR) is presented in Table (2). There was no significant effect ($P<0.05$) on body weight of chicks at 21 and 35 days old as a result of adding phytase. At 49 day old, chicks in T2 group (NPP= 0.262%; 400 g phytase/kg diet) had a significantly ($p<0.05$) higher final body weight compared with chicks from the control and T3 (NPP= 0.128%; 400 g phytase/ kg diet) groups, but not compared with chicks from T1 (NPP= 0.262%; 200 g phytase/ kg diet). Moreover, BW of chicks from T3 did not significantly differ from chicks of the control group. However, phytase supplementation to the diets contain NPP of 0.262% and 0.128% completely corrected the adverse effect of low NPP by releasing the phytate- P. A significant ($P<0.05$) higher FCR in control group compared with chicks from T1, T2 and T3 (2.22, 1.92, 1.83 and 2.08, respectively). These findings agreed with Huff et al. (1998) who reported an increase in body weight on chicks (49 days old) fed low NPP and supplemented with phytase compared with the control. Moreover, the same trend was also reported by many researchers such as Lan et al. (2002) and Ahmed et al. (2000). Many other researchers didn't find any significant improvement in FCR of broilers fed diet supplemented with phytase (Perney et al., 1993; Denbow et al., 1995; Sebastian et al., 1996; Yi et al., 1996 a&b; Huff et al., 1998 and Sohail and Ronald, 1999). On the other hand, Wu et al. (2003) and Cabahug et al. (1999) confirmed our findings by reporting a significant improvement in BW and lower FCR as a result of adding phytase enzyme to broiler diets.

Similar improvement in BW gain of broilers with phytase supplementation of diet has been reported by Simons et al. (1990) and Broz et al. (1994). The improvement of growth performance may be attributed to the release of mineral from the phytate mineral complexes and the utilization of inositol by the chicks (Simons et al., 1990) or to increase starch digestibility (Knuckles and Betschsrt, 1987). The same can also be due to the increased availability of proteins because also phytate makes complexes with proteins, making them less available. Phytate – protein complexes are less subject to proteolytic digestion than the same protein alone. So, it can be postulated that phytase liberated proteins from the complex, may make them more available to the chickens.

The results of FCR were in disagreement with those of Perney et al. (1993); Denbow et al. (1995); Sebastian et al. (1996) and Yi et al. (1996 a&b) who did not find any significant improvement in FCR of broiler chickens fed diet supplemented with phytase. However, others such as Simons et al. (1990) have reported an improvement in FCR until 2 wks of age with supplementing phytase.

Phosphorus and Calcium Concentration in Blood Serum

The effect of phytase supplementation to broiler finisher diet on calcium (Ca, mg/dl) and phosphorus (P, mg/dl) in blood serum of chickens at 21, 35 and 49 days

Table 2. The efficacy of microbial phytase in broiler finisher diet on body weight (BW, Kg) and Feed Conversion Ratio (FCR).

Treatment	Body Weight (BW)			FCR
	21 days old	35 days old	49 days old	
Control [1]	0.632	1.24	2.04[b]	2.22[a]
T1[2]	0.655	1.24	2.24[ab]	1.92[b]
T2 [3]	0.641	1.26	2.56[a]	1.83[b]
T3 [4]	0.644	1.18	2.08[b]	2.08[c]
SE*	0.004	0.01	0.12	0.08
P value	>0.05	>0.05	<0.01	<0.05

[*] Standard error of means
[1] NPP= 0.368%, according to NRC, 1994.
[2] NPP= 0.262% + 200 U Phytase/ kg diet
[3] NPP= 0.262% + 400 U Phytase/ kg diet
[4] NPP= 0.128% + 400 U Phytase/ kg diet

Table 3. The efficacy of adding microbial phytase in broiler finisher diet on concentration of Phosphorus (mg/ dl) in blood serum.

Treatment	**Age**		
	21 days *	**35 days**	**49 days**
Control [1]	4.60±0.26	5.03±0.32[b]	6.90±0.70[b]
T1[2]	4.53±0.06	8.73±0.55[a]	9.80±0.10[a]
T2 [3]	4.46±0.21	8.93±0.74[a]	9.40±0.61[b]
T3 [4]	4.86±0.21	4.96±0.21[b]	6.90±0.26[b]
SE**	0.07	0.59	0.43
P value	> 0.05	< 0.001	0.001

* Mean ± standard deviation
** Standard error of means.
[1] NPP= 0.368%, according to NRC, 1994.
[2] NPP= 0.262% + 200 U Phytase/ kg diet
[3] NPP= 0.262% + 400 U Phytase/ kg diet
[4] NPP= 0.128% + 400 U Phytase/ kg diet

Table 4. The efficacy of adding microbial phytase in broiler finisher diet on concentration of Calcium (mg/ dl) in blood serum.

Treatment	Age		
	21 days*	35 days	49 days
Control [1]	7.13±0.55	7.17±0.81[a]	11.50±0.79[a]
T1[2]	6.97±0.76	12.87±0.55[b]	13.77±1.19[b]
T2 [3]	6.80±1.20	13.00±0.56[b]	14.10±1.09[b]
T3 [4]	7.40±0.90	7.93±1.12[a]	10.60±1.03[ab]
SE**	0.23	0.89	0.51
P value	> 0.05	< 0.01	< 0.001

* Mean ± standard deviation
** Standard error of means.
[1] NPP= 0.368%, according to NRC, 1994.
[2] NPP= 0.262% + 200 U Phytase/ kg diet
[3] NPP= 0.262% + 400 U Phytase/ kg diet
[4] NPP= 0.128% + 400 U Phytase/ kg diet

Table 5. The efficacy of microbial phytase in broiler finisher diet on calcium and phosphorus percentages in drumstick and thigh bone.

Treatment	**Drumstick**		**Thigh**		
	Calcium*	**Phosphorus**	**Calcium**	**Phosphorus**	**Ash%**
Control [1]	33.64±2.58[a]	13.49±0.95[a]	28.82±3.6[a]	13.63±1.10[a]	41.14±0.80[a]
T1[2]	44.35±2.14[b]	14.78±0.63[b]	40.87±3.7[b]	13.86±0.77[ab]	41.9±0.97[a]
T2 [3]	45.05±0.53[b]	15.07±0.68[b]	43.08±1.7[b]	15.07±0.74[b]	42.3±1.3[a]
T3 [4]	31.53±0.91[c]	14.13±0.77[ab]	29.68±1.8[c]	13.58±0.79[a]	40.2±0.69[b]
SE**	1.56	0.23	1.77	0.25	0.23
P value	< 0.001	< 0.05	< 0.001	< 0.05	< 0.05

* Mean ± standard deviation
** Standard error of means.
[1] NPP= 0.368%, according to NRC, 1994.
[2] NPP= 0.262% + 200 U Phytase/ kg diet
[3] NPP= 0.262% + 400 U Phytase/ kg diet
[4] NPP= 0.128% + 400 U Phytase/ kg diet

old are shown in Tables (3 and 4). At 35 days old, P concentration in blood serum of chicks from T1 and T2 groups were significantly ($P<0.001$) higher than in chicks from the control and T3 groups. No significant differences ($P>0.05$) were detected between the control group and T3. Moreover, the same trend was found for Ca concentration for chicks at 35 days old.

At 49 days old, no significant effect ($P>0.05$) of phytase supplementation in chicks from control, T2 and T3, but chicks from T1 showed a significantly higher Ca concentration in blood serum compared with all the other groups. Calcium concentration in serum of chicks from

Table 6. The efficacy of microbial phytase in broiler finisher diet on crude protein andd at percentages in breast, thigh meat and liver (Dry matter basis).

Treatment	Breast		Thigh		Liver	
	CP%*	**Fat%**	**CP%**	**Fat%**	**CP%**	**Fat%**
Control [1]	43.9±.55^{a}	7.06±.18^{ab}	42.6±1.1	7.5±0.06^{a}	66.5±.86	20.2±.78^{ab}
T1 [2]	46.9±1.8^{b}	6.90±.11^{bc}	45.2±2.7	7.1±0.32^{b}	66.2±3.4	19.3±.74^{ab}
T2 [3]	47.8±1.2^{b}	6.80±.^{16c}	45.8±1.2	7.21±0.11^{b}	65.9±1.1	18.5±1.2^{b}
T3 [4]	44.1±.68^{a}	7.10±.11^{a}	43.5±3.4	7.53±0.12^{a}	64.1±3.3	20.7±1.5^{a}
SE**	0.50	0.27	0.59	0.34	0.59	0.33
P value	< 0.001	< 0.05	> 0.05	< 0.001	> 0.05	< 0.05

* Mean ± standard deviation
** Standard error of means.
[1] NPP= 0.368%, according to NRC, 1994.
[2] NPP= 0.262% + 200 U Phytase/ kg diet
[3] NPP= 0.262% + 400 U Phytase/ kg diet
[4] NPP= 0.128% + 400 U Phytase/ kg diet

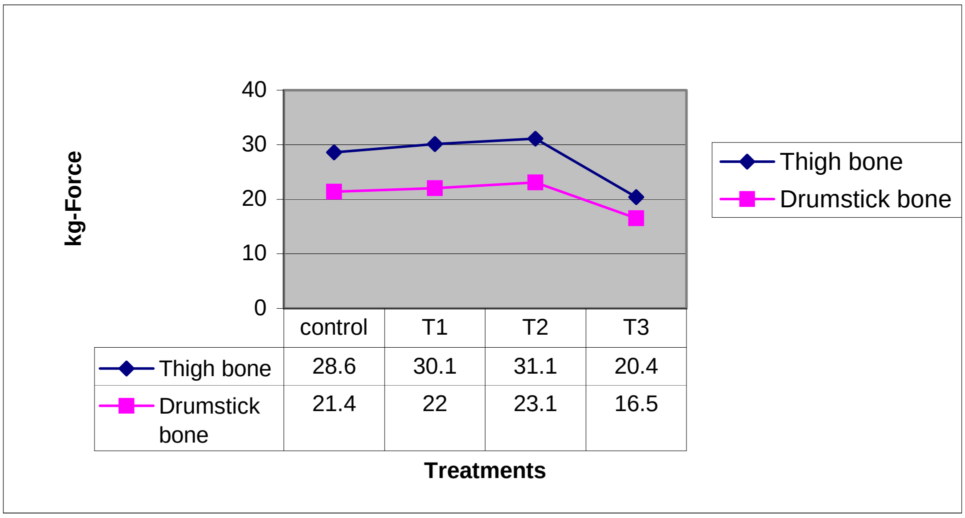

Figure 1. The effect of adding phytase enzyme on broiler thigh and drumstick bone strength.

T1 and T2 were significantly higher (P<0.001) compared with the control group and T3, but there were no differences between the control group and T3.

Rama Rao et al. (1999) reported an increase in P retention when phytase was supplemented to basal diet of broiler. This trend of P retention as a result of phytase supplementation was also reported by many researchers (Schoner et al., 1993; Broz et al., 1994; Kornegay and Qain, 1994 and Yi et al., 1994). Moreover, improvements in the utilization of dietary Ca by supplemental phytase have been reported by Mitchel and Edward (1996) and Zyla et al. (2001). This may explain the higher concentrations of P and Ca in blood serum of chicks in groups supplemented with phytase.

Drumstick and Thigh Bones Ash, Ca, P and Strength

Table (5) shows the percentages of Ca and P and ash in bones from thigh and drumstick. Calcium percentage in the drumstick bones of chicks from T1 and T2 were significantly higher (P<0.001) than those from the control group and T3. No significant differences between chicks in control group and T3 in terms of Ca% were shown. Moreover, the same trend was reported for Ca% in thigh bone, except a significant difference was detected between control group and T3.

Phosphorus percentage in drumstick bone of chicks from T1 and T2 was significantly ($P<0.05$) higher than chicks from the control, but not when compared with chicks from T3. For thigh bone, phosphorus in chicks from T2 was significantly ($P<0.05$) different from the control and T3 chicks, but not when compared with T1 chicks.

The data of thigh and drumstick ash%, showed a significant ($P<0.05$) lower percentage in chicks from T3 compared with the control, T1 and T2, but no differences among control, T1 and T2 were reported. The lower ash% in chicks from group T3 occurred because of the very low NPP (0.128%) available for chicks (0% DCP). The improvement of bone ash% and mineralization may be attributed to one or more of the following mechanisms 1. Increase synthesis or activity of intestinal phytase (Pointillart et al., 1985; Shafey et al., 1991), 2. Increase phytase hydrolysis (Mohammed et al., 1991) with enhancement of the absorption of P and Ca (Wasserman and Tayler, 1973). Phytase supplementation improves bone ash% and mineralization (Ahmed et al., 2000), which may be due to liberation of inorganic P and Ca from the phytate molecule by supplementing phytase. Broz et al. (1994) revealed that phytase supplementation of a maize and soybean meal diet increased the tibia ash of broiler chicks.

Figure 1. presents the effect of phytase supplementation on the Bone Breaking Strength (BBS; kg force) of bones from the drumstick and thigh. The BBS of drumstick and thigh bones of chicks from T1 and T2 were significantly ($P<0.05$) higher compared with the control and T3. Moreover, the BBS of bones of chicks from T3 was significantly ($P<0.05$) lower compared with the control. These observations were supported by bone ash% data. This is because the percentage of bone ash is usually positively correlated with Bone Breaking Strength (BBS) (Rowland et al., 1967). This finding agreed with Sohail and Ronald (1999) who reported a higher BBS of bone from chicks supplemented with phytase enzyme compared with the control. They reported only 34.35+ kg pressure was required to break bone for the control, but 44.4 kg for bones from chicks fed phytase enzyme. In addition, they reported an increase in bone mineral contents with high phytase supplementation levels to broiler diets. These results were also supported by Perney et al. (1993) and Qain et al. (1996) that were in agreement with our findings. Moreover, Zanini and Sazzad (1999) reported an improvement in utilization of N, P, Ca and Zn in the broiler bones as a result of phytase supplementation.

The improvement of bone strength and ash% when chickens were supplemented with dietary phytase suggests an improvement in bone mineralization due to the increase in P and Ca absorption, which was caused by the liberation of inorganic P and Ca from the phytate molecules by the phytase enzyme in the digestive system.

Meat Quality

Table (6) presents the results of the effect of phytase on the Crude Protein percentage (CP%), Fat percentage (Fat%) in breast, thigh meat and liver as dry matter basis. The CP% in breast meat of chicks from T1 and T2 were significantly ($P<0.001$) different compared with chicks from the control and T3. Moreover, no significant ($P>0.05$) changes were found in CP% in the thigh meat and liver with phytase supplementation. Fat percentage in breast meat of chicks from the control and T3 groups showed significant ($P<0.05$) higher values compared with chicks from T2. Chicks from T2 group showed a lower fat%, but not significantly different in chicks from T1. Moreover, the same trend was found in thigh meat fat%, which showed a higher percentage in chicks from the control and T3 groups compared with chicks from T1 and T2 groups. In liver, no significant differences in fat% among the control, T1 and T2 groups, but fat% of chicks from T3 significantly ($P<0.05$) differ from chicks from T2 with only 18.5%. No data were available in the literature to explain the relationship between dietary phytase and chemical composition of broiler meat. Report by Jariwalla et al. (1990) showed that diet supplemented with phytase reduced serum cholesterol, which indicated a relationship with fat metabolism. They suggested that phytase decreased serum cholesterol by affecting zinc:copper ratio, as a phytate is a strong chelator of divalent cations and can be increased by breaking down phytate. Perhaps the ratio of these cations to each other may affect cholesterol/ fat absorption or metabolism.

5. CONCLUSION

The current data demonstrated that with supplementation of 200 or 400 U phytase/ kg diet of broiler, NPP could be reduced by 28.8% from the recommended level by NRC (1994) without any negative effect on their growth and performance by increasing the utilization of phytate- P to compensate the differences. Moreover, phytase supplementations improve bone strength by promoting bone mineralization in broiler. Furthermore, supplementation of phytase improves broiler meat quality by reducing fat% and increasing crude protein percentage.

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كفاءة انزيم الفايتيز الميكروبي للاستفادة من الفسفور غير المتاح لدجاج اللحم من عمر 3-7 أسابيع

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ملخص

تمت دراسة أثر استخدام انزيم الفايتيز لخلطات دجاج اللحم النهائية من عمر 3-7 أسابيع باستخدام 800 صوص لوهمان - قسمت على 4 معاملات ب 4 مكرارات/ معاملة و50 صوصاً بالمكرر. احتوت الخلطات على 3 مستويات فسفور متاح (NPP) (0.368%، 0.262%، 0.128%) و3 مستويات من انزيم الفايتيز (0، 200، 400 وحدة/كجم علف). وكانت الأربع معاملات كما يلي: شاهد (NPP= 0.368% +0 انزيم)؛ T1 (NPP= 0.262%+200 وحدة انزيم)؛ T2 (NPP= 0.262%+400 وحدة انزيم)؛ T3 (NPP=0.128% +400 وحدة انزيم). تم جمع عينات عظام وعينات دم ولحم من الصدر والفخذ وعينة كبد.

عند عمر 49 يوماً، وجدت فروق معنوية (P<0.05) في الوزن النهائي وكذلك في معامل التحويل الغذائي بين المعاملات. تركيز الكالسيوم في الدم والعظام كان مرتفعاً معنوياً (P<0.001) في المجموعتين T1 وT2 مقارنة بالشاهد والمجموعة T3. نسبة الفسفور في عظام منتصف الفخذ كانت أعلى معنوياً (P<0.01) في الطيور من T1 وT3 مقارنة بالشاهد وT2، أما في الفخذ فكانت النسبة أعلى معنوياً في T2 مقارنة بالشاهد وT3. ولوحظ ارتفاع في نسبة البروتين وانخفاض في نسبة الدهن في لحوم الصدر والفخذ في الطيور من المجموعتين T1 وT2. كما ان هنالك تحسناً معنوياً في صلابة العظام في الطيور التي أضيف لها انزيم مع NPP= 0.262%.

في الخلاصة، إضافة انزيم الفايتيز في خلطات دجاج اللحم النهائية تؤدي إلى تحسين أداء الطيور وجودة اللحوم خصوصاً عند تخفيض NPP= 28.8% من المستوى الموصى به بجداول الاحتياجات (NRC).

الكلمات الدالة: الفايتيز، دجاج اللحم، علاف نهائي، فايتيت، عظام.

* قسم الإنتاج الحيواني، كلية الزراعة، جامعة مؤتة، الكرك، الأردن. تاريخ استلام البحث 2005/9/19، وتاريخ قبوله 2006/5/10.