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Estimation of the Dietary Calcium and Nonphytate Phosphorus Needs of Growing Commercial Tom Turkeys Weighing Four to Twelve Kilograms

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Abstract: An experiment was conducted to evaluate the dietary calcium and phosphorus needs of commercial toms during the grower feeding period of 8 to 14 wk of age. Dietary calcium and nonphytate phosphorus were formulated to be fed at 60, 75, 90, 105 or 120% of the NRC (1994) requirements based upon three-wk phase feeding periods. A corn-soybean meal based diet was fed in mash form to Large White turkeys that had been fed adequate calcium and nonphytate phosphorus for 8 wk and weighed an average of 4.44 kg at the start of the experiment. Growth was improved linearly from 8 to 11 wk of age and for the entire experiment by increasing amounts of dietary calcium and nonphytate phosphorus. Bone strength, as measured by fracture force, was increased linearly at 11 and 14 wk of age by increasing levels of dietary calcium and nonphytate phosphorus. Based upon analyzed nutrient values and feed disappearance, it was estimated that growing toms need approximately 2 g of nonphytate phosphorus per day during the growing period when a calcium:nonphytate phosphorus ratio of approximately 2:1 is fed and the toms are gaining about 180 g/d.

Key words: Bone, calcium, phosphorus, tom, turkey

Introduction

Studies to determine the calcium and phosphorus requirements of growing-finishing Large White toms have not been conducted in almost 40 years (Sullivan, 1962; Day and Dilworth, 1962). Although the improved genetics of today imply increased nutrient requirements to support faster growth, published data is lacking to support the concentrations of dietary calcium and phosphorus that are recommended by turkey breeding companies. In addition to growth performance, high levels of calcium and phosphorus are fed due to concerns about leg weakness and other disorders associated with leg weakness such as breast blisters. A safety factor is usually included to ensure that all the birds consume adequate phosphorus since there may be variability in the phosphorus level in the feed.

The NRC (1994) requirement for nonphytate phosphorus (npP) for starting poults is 0.60% based upon past research (Almquist, 1954; Bailey *et al*., 1986). Calcium is recommended at 1.20% to provide a 2:1 ratio of calcium and npP and is supported by the report of Neagle *et al*. (1968). However, more recent research with 16-d-old poults resulted in estimates of 1.25% calcium and 1.00% total P (0.72% npP) for requirements of young turkeys (Sanders *et al*., 1992).

Atia *et al*. (2002) reported that male and female turkeys grown from 4 wk of age to market age grew just as well and had similar bone characteristics when 73% of the npP NRC (1994) requirements were fed as when the birds were fed 110% of the NRC (1994) requirements for calcium and npP. Ledoux *et al*. (1995) did not observe growth, bone or phosphorus digestibility responses to phytase when approximately 70% of the NRC (1984) requirement for available phosphorus was fed to turkey hens. The NRC (1984) requirements for available phosphorus are identical to the NRC (1994) requirements for npP. Hocking *et al*. (2002) concluded that Large White male turkeys should be fed 1.00% calcium and 0.30% available phosphorus from 4 to 13 wk of age to optimize growth and feed efficiency without affecting walking ability. Hence, the calcium and phosphorus levels needed today for optimum growth performance and leg strength of commercial tom turkeys are disputed. The objective of this study is to estimate the calcium and npP needs of Large White commercial toms with respect to growth performance and bone strength in the grower feeding period of 8 to 14 wk of age.

Materials and Methods

Nicholas 700 male poults were obtained from a commercial hatchery and group brooded at 50 poults/pen in 8 pens (2.46 m X 3.08 m) to 3 wk of age. The poults were then separated into 15 treatment pens with about 24 poults/pen from 3 to 8 wk of age. All birds were fed a common diet that was formulated to meet NRC (1994) requirements for calcium and nonphytate phosphorus (npP) and meet or exceed all other nutrient requirements. Formulations for the pre-starter, starter I, or starter II diets were fed from 0-16 d, 16-35 d, or 35-56 d, respectively. Diet changes were made to correspond similarly with the footnote *a* reference under Table 3 and 1 in the NRC (1994) guidelines which states that due to genetic improvements in body weight gain,

Table 1: Percentage composition of the experimental diets

Ingredient	Grower I (8 to 11-wk of age)					Grower II (11 to 14-wk of age)				
	% of NRC requirement									
	60	75	90	105	120	60	75	90	105	120
Ground yellow corn	61.00	60.06	59.11	58.19	57.25	65.70	64.88	64.06	63.23	62.40
Dehulled soybean meal	31.40	61.60	31.75	31.95	32.10	25.80	25.95	26.10	26.25	26.40
Choice white grease	4.57	4.90	5.26	5.60	5.95	5.71	6.01	6.32	6.62	6.92
Dicalcium phosphate	0.60	0.90	1.20	1.51	1.82	0.48	0.75	1.02	1.29	1.56
Limestone	0.58	0.70	0.82	0.93	1.06	0.55	0.66	0.76	0.87	0.98
Salt	0.40	0.40	0.40	0.40	0.40	0.36	0.36	0.36	0.36	0.36
L-lysine-HCl	0.21	0.20	0.20	0.19	0.19	0.16	0.16	0.16	0.15	0.15
DL-methionine	0.18	0.19	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18
Vitamin mix[1]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Trace mineral mix[2]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Celite	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Formulated nutrient levels										
Calcium, %	0.45	0.56	0.68	0.80	0.90	0.40	0.50	0.60	0.70	0.80
Nonphytate P, %	0.23	0.28	0.34	0.40	0.45	0.20	0.25	0.30	0.35	0.40
Analyzed nutrient levels										
Calcium, %	0.44	0.53	0.69	0.87	0.93	0.44	0.55	0.65	0.66	0.71
Total P, %	0.46	0.53	0.58	0.66	0.62	0.42	0.49	0.49	0.55	0.58
Phytate P, %	0.23	0.24	0.24	0.25	0.24	0.22	0.23	0.22	0.22	0.27
Calculated nutrient levels										
Nonphytate P, %	0.23	0.29	0.34	0.41	0.38	0.20	0.26	0.27	0.33	0.31

[1]Vitamin premix provided per kg diet: vitamin A (all-trans-retinyl acetate), 11,000 IU; cholecalciferol, 5,000 ICU; vitamin E (all-rac-α-tocopherol acetate), 35 IU; menadione (as menadione sodium bisulfite), 2.75 mg; riboflavin, 10 mg; Ca pantothenate, 20 mg; nicotinic acid, 80 mg; vitamin B_{12}, 0.025 mg; vitamin B_6, 4.3 mg; thiamin (as thiamin mononitrate), 2.9 mg; folic acid, 2.2 mg; biotin, 0.2 mg; vitamin C, 0.10 g; selenium, 0.275 mg; and ethoxyquin, 125 mg. [2]Mineral premix supplied per kg of diet: manganese, 100 mg; zinc, 100 mg; iron, 50 mg; copper, 10 mg; iodine, 1 mg.

implementation of the listed nutrient requirements are on a three-wk basis by the industry at large. The diets were mixed at the Michigan State University feed mill and were fed in a mash form because there is no pelleting equipment at the feed mill.

The experiment began when the toms were 8 wk of age and the average starting body weight was 4.44 kg. The diets were fed in two phases for a total of 6 wk until the toms were 14 wk of age. The dietary treatments were formulated to contain 60, 75, 90, 105 or 120% of the NRC (1994) requirements for npP in the three-wk interval format (Table 1). Hence, the NRC (1994) requirements for npP in the grower I and grower II phases are 0.38 and 0.32%, respectively. Dietary calcium was maintained at a 2:1 ratio with npP for all diets. The diets were analyzed for calcium and phosphorus by plasma emission spectroscopy at a commercial laboratory and for phytate phosphorus by the method described by Latta and Eskin (1980). The feed was supplied in plastic hanging tube feeders and water was supplied by bell drinkers. Celite was fed as an indigestible marker to measure phosphorus digestibility. However, adequate sampling of fresh excreta was difficult to obtain under the experimental conditions so this parameter was not measured.

Body weight was measured individually at 11 and 14 wk of age. Feed was weighed back at the end of each three-wk phase and feed disappearance was used to estimate feed intake. At both 11 and 14 wk of age, 4 birds/pen were selected based upon the average body weight of the pen for bone analyses. Birds selected at 11 wk of age were euthanized with Na pentobarbital and the left ulna, femur, humerus, and both tibiae were excised for bone strength testing. Birds selected at 14 wk of age were slaughtered at the Michigan State University Meat Laboratory and the ulna, femur, humerus, and tibia were taken from the left side of the carcass after a 4-h chill. The bones were cleaned and frozen until analyzed for bone strength testing using an Instron Universal Testing Machine. Bones were thawed overnight in a cooler before breaking strength was tested. The left ulna, femur, tibia, and humerus were tested using the double block shear method and the tibia was broken by the three-point bend method (ASAE, 1999). The data are reported as bone fracture force which is the maximum amount of force applied to the mid-shaft of the bone that is required to break the bone.

Data were analyzed by the General Linear Models procedure of SAS (SAS Institute, 2000). Regression analysis was conducted to test for linear and quadratic

Table 2: Effect of dietary calcium and nonphytate phosphorus (npP) levels on growth performance of tom turkeys[1]

		8-11 wk			11-14 wk			8-14 wk	
Treatment % of NRC[2] requirement		8-wk Body Weight (kg)	Average Daily Gain (g/d)	Gain: feed (g:g)	11-wk Body Weight (kg)	Average Daily Gain (g/d)	Gain: feed (g:g)	Average Daily Gain (g/d)	Gain: feed (g:g)
60		7.85[b]	169[b]	0.348	11.76	181	0.285	175	0.319
75		8.04[a]	177[a]	0.354	11.89	174	0.282	176	0.317
90		7.99[ab]	177[a]	0.350	12.28	189	0.280	185	0.320
105		8.06[a]	180[a]	0.349	12.26	186	0.278	183	0.315
120		8.15[a]	184[a]	0.355	12.42	186	0.262	187	0.311
Mean		8.02	177	0.351	12.12	183	0.277	181	0.317
SEM		0.05	2	0.005	0.18	5	0.007	4	0.003
Analysis of variance	df								
Treatment	4	0.020	0.015	0.801	0.122	0.286	0.209	0.120	0.479
Regression analysis									
Linear		0.003	0.001	0.612	0.008	0.170	0.029	0.011	0.118
Quadratic		0.727	0.594	0.925	0.554	0.821	0.277	0.586	0.278

[a-b]Means with no common superscripts are different at p<0.05. [1]Treatment means are based upon 3 pens of about 24 toms/pen from 8 to 11 wk of age and 3 pens of about 20 toms/pen from 11-14 wk of age. [2]National Research Council (1994); calculated calcium and npP levels based upon a three-wk feeding phase method.

Table 3: Effect of dietary calcium and nonphytate phosphorus (npP) levels on bone fracture force of tom turkeys

Treatment	11 wk					14 wk			
% of NRC	Shear				Three-point bend	Shear			
requirement	Femur	Humerus	Tibia	Ulna	Tibia	Femur	Humerus	Tibia	Ulna
	(N)								
60	1255	2108[b]	2167[c]	1244[c]	375[c]	1451	2293[c]	2631[b]	1260
75	1422	1901[b]	2778[c]	1223[c]	464[bc]	1520	2757[bc]	3302[a]	1542
90	1443	2234[b]	2721[b]	1554[b]	438[bc]	1650	3302[ab]	3792[a]	1643
105	1674	2923[a]	3217[a]	1890[a]	603[a]	1675	3582[a]	3809[a]	2072
120	1715	2490[ab]	2932[b]	1571[b]	533[ab]	1773	3209[ab]	3405[a]	1653
Mean	1502	2331	2763	1496	483	1614	3029	3388	1634
SEM	137	180	120	92	40	101	213	194	158
Analysis of variance	df								
Treatment	4	0.181	0.021	0.001	0.003	0.020	0.249	0.012	0.009	0.053
Regression analysis									
Linear		0.010	0.021	0.002	0.006	0.007	0.015	0.005	0.028	0.036
Quadratic		0.918	0.902	0.035	0.220	0.470	0.879	0.025	0.002	0.110

[a-c]Means with no common superscript are different at p<0.05. [1]Treatment means are based upon an average of 3 or 4 bones per pen and 3 pens per treatment from toms at 11 or 14 wk of age. [2]National Research Council (1994); calculated calcium and npP levels based upon a three-wk feeding phase method.

effects of dietary calcium and npP levels. Where appropriate, individual treatment means were separated by the Duncan's multiple range test. The procedures utilized in this study were approved by the All-University Committee for Care and Use of Animals at Michigan State University.

Results and Discussion

There were linear increases in 11-wk body weight (p=0.003) and average daily gain (p=0.001) in the grower I (8 to 11-wk) phase as dietary calcium and phosphorus were increased (Table 2). This difference in body weight was due to differences in feed intake as there was no feed efficiency response. Body weight at 14-wk of age was also increased linearly (p=0.008) as dietary calcium and phosphorus increased. There was not a significant daily gain effect in the grower II (11 to 14-wk) phase. Birds fed the higher levels of calcium and npP had higher feed disappearance again, but feed wastage appeared to contribute to the linear reduction (p=0.029) in feed efficiency (gain:feed) as dietary calcium and phosphorus increased. Average daily gain was increased linearly (p=0.011) for the entire growing period of 8 to 14 wk by increasing dietary calcium and phosphorus levels. There was no significant effect on feed efficiency for the overall growing period.

Bone strength was increased linearly (p<0.05) at both 11 and 14 wk of age for all bones tested (Table 3). The quadratic model was more appropriate (p=0.002) for the tibia shear force test at 14 wk of age. The treatment providing dietary calcium and npP at 105% of the NRC (1994) requirement on a three-wk basis was adequate

to maximize bone strength for all bones except the femur. Analyzed values of dietary calcium and phosphorus showed that the diets formulated to provide 120% of the NRC (1994) requirement were lower in npP than expected. This likely contributed to the highest bone strength values typically being associated with the next lowest dietary calcium and phosphorus group. However, the linear response was strongest for femur breaking strength especially at 14 wk of age. Dietary calcium levels were actually the highest in the group formulated to receive 120% of the NRC (1994) requirements for calcium and npP. Lilburn (1993) suggested that the femur may be the weak link with respect to long bone developmental abnormalities.

Based upon feed disappearance in this experiment, the npP requirement is about 2 g/d. The feed disappearance measured in this experiment is about 30% higher than intake levels predicted by the breeding company during the 8 to 14-wk period which would be based upon pelleted feeds. The npP requirement based upon feed intake and suggested percent npP requirement listed by the breeder company is about 20% higher than the estimation from this experiment. Rodehutscord *et al.* (2003) recently reported that British United Turkeys Big 6 toms grew well and did not have locomotor difficulties when an average of about 25% less dietary phosphorus than recommended by the breeder company was fed from 10 to 22 wk of age. The data in the current experiment supports feeding calcium and npP levels slightly higher than the NRC (1994) requirements on a three-wk basis to improve bone strength which disagrees with reports by Atia *et al.* (2002) and Ledoux *et al.* (1995) who fed turkeys on a four-wk basis. Although the estimated requirements in this study are not largely different than the reports of Sullivan (1962) and Day and Dilworth (1962) on a percentage basis, the requirement on a g/d basis is higher due to greater feed intake and faster growth of turkeys compared to 40 yr ago. Due to the importance of phosphorus in nutrient management planning to address environmental concerns about water quality, more research is needed to confirm the dietary phosphorus needs of turkeys in the growing and finishing phases.

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