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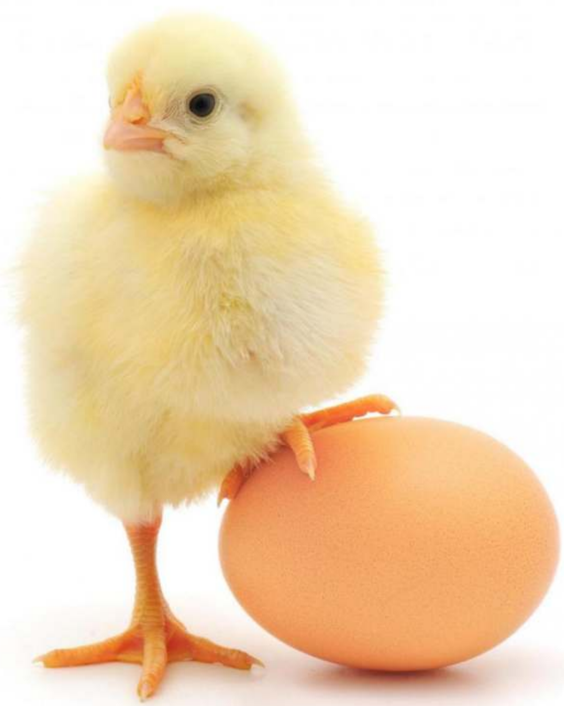

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Comparison of Normal and High Available Phosphorus Corn With and Without Phytase Supplementation in Diets for Male Large White Turkeys Grown to Market Weights[1]

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Abstract: Large White turkeys were fed diets containing either normal yellow dent corn (YDC) or a corn mutation containing low phytate phosphorus and high available phosphate corn (HAPC). Diets were considered nutritionally adequate in all respects with various degrees of reduction in available phosphorus content (- 0.0, - 0.05, - 0.10 or - 0.15% of NRC (1994) recommendations for different feeding periods). These diets were fed with or without the addition of 1000 U/kg of phytase enzyme (Natuphos®, BASF), resulting in a total of 16 dietary treatments. Each treatment was assigned to three pens of 20 male turkeys from day-old to 20 wk of age. Body weight, feed consumption, and tibia ash were determined at 28 d intervals during the study. Male turkeys fed diets with HAPC did not differ significantly in BW or feed conversion (FC) from those fed diets with YDC, and had significantly higher tibia ash at 4, 8, and 12 wk of age. Addition of 1000 U/kg of phytase resulted in significantly higher BW at 4, 8, 12, and 16 wk of age as compared to unsupplemented controls with no significant differences in FC. The addition of phytase significantly improved tibia ash at every age. Dietary phosphorus content had no effect on BW or FC at any age. Reduction of phosphorus generally did not impair tibia ash until reduction of 0.15% below NRC (1994) recommendations. Addition of phytase aided in overcoming the reduction in phosphorus content. The combination of HAPC, addition of phytase, and reduction in dietary phosphorus content should aid in reducing phosphorus excretion without impairing performance.

Key words: Turkeys, phosphorus, high available phosphorus corn, phytase

Introduction

Many people are concerned about the contribution of phosphorus runoff from the application of poultry litter to eutrophication of surface waters. This has focused considerable attention on means of reducing phosphorus excretion by poultry (Edwards and Daniel, 1992; Sharpley, 1999; Waldroup, 1999). A considerable amount of the phosphorus in poultry diets is in the form of phytate phosphorus, an organically bound storage form of phosphorus that is poorly digested by monogastric animals that are lacking or limiting in phytase, the enzyme that is necessary for breakdown of the phytate molecule and subsequent release of the phosphorus for absorption (O'Dell *et al.*, 1972; Raboy, 1990). Sullivan (1960) stated that turkeys 8-20 wk of age apparently do not utilize the phytin phosphorus in feedstuffs of plant origin to any extent. However, Andrews *et al.* (1972a, 1972b) suggested that young poults could use a large portion of the organic phosphorus in the diet, depending upon the ingredient source used.

Nelson *et al.* (1968, 1971) demonstrated that addition of phytase to broiler diets improved the availability of phytate-bound phosphorus. Recent commercial development of phytase enzymes offers promise in reducing phosphorus excretion by increasing the ability of the chick to utilize a portion of the phytate-bound phosphorus (Ravindran *et al.*, 1995a; Sebastian *et al.*, 1998). Turkey poults have been shown to respond favorably to the addition of phytase to diets low in phosphorus (Ravindran *et al.*, 1995b; Qian *et al.*, 1996a, 1996b). The addition of 652 U/kg of phytase was equivalent to addition of 1 g/kg of P from defluorinated phosphate in turkey starter diets (Ravindran *et al.*, 1995b; Qian *et al.*, 1996a).

Another approach to reducing phosphorus in excreta is to develop feedstuffs with modified levels of phytate-bound phosphorus. A corn mutation with low phytate phosphorus and high available phosphorus content has been developed by the USDA (Raboy and Gerbasi, 1996; Raboy, 1997) and has been bred into hybrid corn by a

[1]Published with approval of the Director, Arkansas Agricultural Experiment Station, Fayetteville AR 72701. Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the authors or the University of Arkansas and does not imply its approval to the exclusion of other products that may be suitable.

Table 1: Nutrient profile of normal yellow dent corn (YDC) and high available phosphorus corn (HAPC) on an as-fed basis[1]

Nutrient	YDC	HAPC
TME, kcal/kg	3596.20	3582.67
Dry matter, %	88.13	86.61
Crude protein, %	8.88	8.80
Crude fiber, %	1.90	1.90
Ash, %	1.01	1.20
Crude fat, %	3.79	3.76
Ca, %	0.008	0.009
Total P, %	0.23	0.27
Phytate P, %	0.20	0.10
Nonphytate P, %	0.03	0.17
Alanine, %	0.61	0.61
Arginine, %	0.31	0.33
Aspartic acid, %	0.58	0.59
Cystine, %	0.15	0.17
Glutamic acid, %	1.57	1.56
Glycine, %	0.29	0.30
Histidine, %	0.26	0.27
Isoleucine, %	0.28	0.28
Leucine, %	1.06	1.03
Lysine, %	0.21	0.22
Methionine, %	0.13	0.15
Phenylalanine, %	0.41	0.40
Proline, %	0.75	0.81
Serine, %	0.40	0.41
Threonine, %	0.30	0.30
Tyrosine, %	0.16	0.16
Tryptophan, %	0.05	0.05
Valine, %	0.38	0.39

[1]Values provided by Pioneer Hi-Bred International Inc., Johnston IA.

major seed company[2] using the low phytic acid 1-1 (*lpal-1*) allele of the corn LPA1 gene. This hybrid, designated as high available phosphate corn (HAPC), contains approximately 0.27% total phosphorus, of which 0.17% is estimated to be available to the chicken. The nonphytate portion of HAPC has been found to be equivalent in biological value to a commercial dicalcium phosphate for broilers (Ertl *et al.*, 1998; Waldroup *et al.*, 2000). In contrast, normal yellow dent corn (YDC) contains similar levels of total phosphorus but only about 0.08% available phosphorus (NRC, 1994). Previous studies have shown HAPC to be nutritionally equal or superior to YDC in broiler diets with a reduction in excreta phosphorus (Huff *et al.*, 1998; Waldroup *et al.*, 2000; Yan *et al.*, 2000). To our knowledge no studies have been reported on use of this corn genotype in diets for turkeys. Because corn makes up a very large percentage of turkey feeds, a trial was conducted to evaluate the use of HAPC in diets for male turkeys grown to market weights.

Materials and Methods

Supplies of normal yellow dent corn (YDC) and high available phosphorus corn (HAPC) were obtained from a major corn breeder. The YDC used in the study was the isogeneic normal phytate counterpart of the HAPC. Both corns were grown in the same geographic location during the same year. Nutrient values for the two corn types are shown in Table 1.

Diets were formulated using each of the corn types along with soybean meal as major sources of protein and energy to meet the nutritional needs of growing turkeys. The diets contained a minimum of 110% of the amino acid recommendations suggested by the NRC (1994). Base diets were formulated to contain NRC recommended levels of calcium and nonphytate phosphorus. Complete vitamin and trace mineral mixes obtained from a commercial turkey producer were used to supplement the diets. Composition of the diets is shown in Table 2.

By reduction in the amounts of feed-grade dicalcium phosphate and adjustments in amounts of ground limestone and washed builders sand, a series of test diets were produced from each corn type that contained reduced levels of nonphytate phosphorus (- 0.0%, - 0.05%, - 0.10%, - 0.15% below NRC for each test period) while maintaining recommended calcium levels. Each of these diets was then fed with or without 1000 U/kg phytase enzyme[3]. This resulted in a 2 x 4 x 2 factorial arrangement with two corn types (YDC and HAPC), four levels of nonphytate phosphorus reduction from NRC recommendations (-0.0, -0.05, -0.10 and –0.15%), and two phytase levels (0 and 1000 U/kg) for a total of sixteen experimental treatments. Each of these was assigned to three pens of 20 male turkeys. Diets were fed in mash form to avoid problems related to destruction of the phytase enzyme during pelleting or uniform application of phytase enzyme to pelleted diets.

Nine hundred and sixty (960) day-old male poults of a commercial Large White strain[4] were obtained from a local hatchery and randomly assigned among 48 litter floor pens (11.2 M2) in a house of commercial design. New softwood shavings over concrete floor served as litter. Each pen was equipped with two tube feeders and an automatic water fount. Supplemental feeders and water founts were used for the first 7 d. At 8 wk a small range-type feeder replaced the tube feeders. Automatic brooder stoves, ventilation fans, and sidewall curtains

[2]Pioneer Hi-Bred International, Inc., Johnston IA 50131. [3]Natuphos®, BASF Corporation, Mt. Olive NJ 07828. One unit of phytase activity is defined as the quantity of enzyme required to produce one µmol of inorganic P/min from 5.1 mmol/L of sodium phytate at a pH of 5.5 and a water bath temperature of 37 °C. [4]Nicholas 700. Nicholas Turkey Breeder Farms, Sonoma CA 95476.

Table 2: Composition (g/kg) and calculated nutrient content[1] of experimental diets with yellow dent corn (YDC) or high available phosphorus corn (HAP) for growing turkeys

Ingredient	0-4 wk		4-8 wk		8-12 wk		12-16 wk		16-20 wk	
	YDC	HAP	YDC	HAP	YDC	HAP	YDC	HAP	YDC	HAP
Yellow dent corn	408.18	0.00	445.62	0.00	561.44	0.00	669.51	0.00	728.71	0.00
HAP corn	0.00	412.45	0.00	450.19	0.00	567.21	0.00	676.52	0.00	736.33
Soybean meal (48%)	522.88	522.14	487.32	486.60	380.52	379.59	278.78	277.55	218.83	217.49
Dicalcium phosphate	24.89	22.21	19.79	16.86	16.36	12.67	15.05	10.66	12.33	7.55
Limestone	13.67	15.13	11.53	13.13	10.22	12.24	9.02	11.42	8.31	10.93
Poultry oil	12.98	10.74	20.49	18.05	15.83	12.76	13.23	9.55	19.27	15.27
Iodized salt	5.79	5.90	4.53	4.65	4.54	4.69	4.54	4.72	4.55	4.75
Vitamin premix[2]	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
DL Methionine (98%)	3.05	2.96	2.32	2.22	1.79	1.67	1.21	1.07	0.76	0.60
L-Lysine HCl (98%)	1.56	1.47	1.40	1.30	2.30	2.17	1.63	1.48	0.92	0.76
L-Threonine	0.00	0.00	0.00	0.00	0.00	0.00	1.03	1.03	0.32	0.32
Trace minerals[3]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Coban-60[4]	0.50	0.50	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00
BMD-50[5]	0.50	0.50	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00
ME, kcal/kg	2800.00	2800.00	2900.00	2900.00	3000.00	3000.00	3100.00	3100.00	3200.00	3200.00
Crude protein, %	28.74	28.67	27.32	27.26	23.32	23.23	19.41	19.31	16.94	16.82
Calcium, %	1.20	1.20	1.00	1.00	0.85	0.85	0.75	0.75	0.65	0.65
Total P, %	0.88	0.85	0.78	0.74	0.67	0.63	0.61	0.56	0.54	0.48
Nonphytate P, %	0.60	0.60	0.50	0.50	0.42	0.42	0.38	0.38	0.32	0.32
Methionine, %	0.71	0.71	0.62	0.61	0.51	0.51	0.40	0.39	0.32	0.32
Lysine, %	1.76	1.76	1.65	1.65	1.43	1.43	1.10	1.10	0.88	0.88
TSAA, %	1.16	1.16	1.05	1.05	0.88	0.88	0.72	0.72	0.61	0.61
Threonine, %	1.10	1.10	1.05	1.05	0.88	0.88	0.83	0.83	0.66	0.66

[1]Calculated from NRC (1994) and from values for corn shown in Table 1. [2]Provides per kg of diet: vitamin A (from vitamin A acetate) 16,520 IU; cholecalciferol 7,200 IU; vitamin E (from dl-alpha-tocopheryl acetate) 50 IU; vitamin B_{12} 0.022 mg; riboflavin 13.75 mg; niacin 105 mg; pantothenic acid 30.25 mg; menadione (from menadione dimethylpyrimidinol) 3.85 mg; folic acid 2.2 mg; choline 1040 mg; thiamin (from thiamin mononitrate) 3.3 mg; pyridoxine (from pyridoxine HCl) 5.5 mg; d-biotin 0.181 mg; ethoxyquin 125 mg; Se 0.275 mg. [3]Provides per kg of diet: Mn (from $MnSO_4 \cdot H_20$) 100 mg; Zn (from $ZnSO_4 \cdot 7H_2O$) 100 mg; Fe (from $FeSO_4 \cdot 7H_2O$) 50 mg; Cu (from $CuSO_4 \cdot 5H_20$) 10 mg; I from $Ca(IO_3)_2 \cdot H_20$), 1 mg. [3]Elanco Animal Health division of Eli Lilly & Co., Indianapolis, IN 46825.[5]Alpharma, Inc., Ft. Lee, NJ 07024.

controlled temperature and airflow rates. Bird management and care followed approved guidelines (FASS, 1999).

The birds were placed on their respective test diets at one day of age and fed to 20 wk with the test diets and tap water provided for ad libitum consumption. At 28 d intervals the birds were individually weighed, feed consumption for the period determined, and new feed added. At these intervals, two birds per pen, nearest the pen mean, were killed and the tibia removed for ash determination of dry fat-free bone as described by AOAC (1990). The birds were checked twice daily and the weight of dead birds determined for adjustment of feed consumption.

Table 3: Effects of normal yellow dent corn and high available phosphate corn fed with or without phytase supplementation on body weight (kg) of male Large White turkeys

Corn Type[1]	Added Phytase[2]	P Level[3]	Age (weeks)				
			4	8	12	16	20
Corn type							
YDC	----	-----	0.971	3.961	7.942	12.467	17.074
HAPC	----	-----	0.990	3.975	8.108	12.647	17.060
Added phytase							
----	No	-----	0.955[b]	3.886[b]	7.847[b]	12.428[b]	16.993
----	Yes	-----	1.006[a]	4.051[a]	8.202[a]	12.755[a]	17.142
Phosphorus level							
----	----	NRC	0.981	4.021	8.229	12.705	17.058
----	-----	- 0.05	0.989	4.036	8.088	12.600	17.116
----	-----	- 0.10	0.991	3.910	7.846	12.516	17.180
----	-----	- 0.15	0.961	3.905	7.936	12.543	16.914
Source of variation			Probability > F				
Corn type (C)			0.09	0.78	0.13	0.28	0.91
Phosphorus Level (L)			0.24	0.20	0.08	0.66	0.54
Phytase (P)			0.0001	0.005	0.002	0.003	0.28
C x L			0.70	0.41	0.78	0.58	0.66
C x P			0.48	0.47	0.57	0.60	0.17
L x P			0.12	0.79	0.88	0.30	0.32
C x L x P			0.08	0.13	0.49	0.22	0.80
SEM			0.03	0.11	0.25	0.24	0.30

[ab]Means in columns with no common superscripts differ significantly ($P \leq 0.05$). [1]YDC = Yellow dent corn; HAPC = High available phosphate corn. [2]With or without addition of 1000 U/kg phytase (Natuphos®, BASF, Mt. Olive NJ). [3]Reduction from NRC (1994) recommended levels within each period.

Table 4: Effects of normal yellow dent corn and high available phosphate corn fed with or without phytase supplementation on feed conversion (kg feed:kg gain) of male Large White turkeys

Corn Type[1]	Added Phytase[2]	P Level[3]	Age (weeks)				
			0-4	0-8	0-12	0-16	0-20
Corn type							
YDC	----	-----	1.419	1.804	2.221	2.642	2.914
HAPC	----	-----	1.390	1.811	2.247	2.649	2.927
Added phytase							
----	No	-----	1.400	1.826	2.239	2.651	2.935
----	Yes	-----	1.406	1.788	2.229	2.640	2.906
Phosphorus level							
----	-----	NRC	1.364	1.780	2.197	2.610	2.887
----	-----	- 0.05	1.402	1.780	2.209	2.653	2.943
----	-----	- 0.10	1.432	1.839	2.293	2.691	2.974
----	-----	- 0.15	1.414	1.798	2.237	2.629	2.878
Source of variation			Probability > F				
Corn type (C)			0.29	0.76	0.46	0.85	0.81
Phosphorus Level (L)			0.29	0.32	0.23	0.53	0.55
Phytase (P)			0.80	0.10	0.78	0.79	0.60
C x L			0.65	0.68	0.08	0.75	0.32
C x P			0.67	0.53	0.82	0.81	0.79
L x P			0.28	0.96	0.42	0.38	0.18
C x L x P			0.91	0.54	0.99	0.86	0.62
SEM			0.058	0.053	0.069	0.096	0.108

[1]YDC = Yellow dent corn; HAPC = High available phosphate corn. [2]With or without addition of 1000 U/kg phytase (Natuphos®, BASF, Mt. Olive NJ). [3]Reduction from NRC (1994) recommended levels within each period.

Table 5: Effects of normal yellow dent corn and high available phosphate corn fed with or without phytase supplementation on tibia ash (% dry fat-free bone) of male Large White turkeys

Corn Type[1]	Added Phytase[2]	P Level[3]	Age (weeks) 4	8	12	16	20
Corn type							
YDC	----	-----	46.52[b]	49.61[b]	51.46[b]	54.09	55.43
HAPC	----	-----	47.51[a]	50.02[a]	52.29[a]	54.24	55.68
Added phytase							
----	No	-----	46.85[b]	49.32[b]	50.99[b]	53.63[b]	55.19[b]
----	Yes	-----	47.17[a]	50.31[a]	52.76[a]	54.70[a]	55.92[a]
Phosphorus level							
----	----	NRC	47.47[a]	50.05	51.62[ab]	54.16	55.54
----	-----	- 0.05	47.26[a]	49.85	52.55[a]	54.58	55.89
----	-----	- 0.10	47.05[a]	49.88	52.42[a]	54.46	55.93
----	-----	- 0.15	46.28[b]	49.49	50.89[b]	53.47	54.85
Phytase x Phosphorus level							
----	No	NRC	47.82[a]	49.43	51.06	53.66	55.34
----	No	- 0.05	46.88[ab]	49.67	51.49	53.68	55.11
----	No	- 0.10	47.39[ab]	49.58	51.98	54.47	56.08
----	No	- 0.15	45.32[c]	48.63	49.42	52.72	54.21
----	Yes	NRC	47.12[ab]	50.67	52.18	54.65	55.74
-----	Yes	- 0.05	47.64[ab]	50.03	53.62	55.46	56.67
----	Yes	- 0.10	46.71[b]	50.18	52.87	54.45	55.77
----	Yes	- 0.15	47.23[ab]	50.34	53.37	54.21	55.49
Source of variation			Probability > F				
corn type (C)			0.0007	0.08	0.04	0.73	0.52
Phosphorus Level (L)			0.01	0.41	0.02	0.24	0.18
Phytase (P)			0.02	0.0002	0.0001	0.01	0.05
C x L			0.15	0.16	0.85	0.60	0.45
C x P			0.36	0.21	0.31	0.13	0.17
L x P			0.003	0.18	0.24	0.44	0.31
C x L x P			0.36	0.30	0.76	0.34	0.30
SEM			0.62	0.55	0.79	0.82	0.76

[abc]Means in column with no common superscript differ significantly ($P \leq 0.05$). [1]YDC = Yellow dent corn; HAPC = High available phosphate corn. [2]With or without addition of 1000 U/kg phytase (Natuphos®, BASF, Mt. Olive NJ). [3]Reduction from NRC (1994) recommended levels within each period.

Pen means served as the experimental unit. The data were analyzed as a factorial arrangement of treatments using the General Linear Models procedure of SAS (SAS Institute, 1991). The main effects included corn type, phosphorus level, and Phytase supplementation with all possible two-way and three-way interactions. Where significant differences were observed among or between treatment means, data were separated by repeated t tests using the lsmeans option of SAS. Statements of probability are based on $P \leq 0.05$).

Results and Discussion

Body weight: Body weight of male Large White turkeys at different ages is shown in Table 3. No significant differences were observed between turkeys fed the two different types of corn at any age. Birds fed the diets supplemented with 1000 U/kg phytase were significantly heavier than the non-supplemented controls at 4, 8, 12, and 16 wk of age and were numerically heavier at 20 wk. The phosphorus level of the diet had no significant effect on body weight at any age. There were no significant interactions among or between any of the main effects for body weight.

Feed conversion: Feed conversion, expressed as kg feed per kg gain, is shown in Table 4. There were no significant effects of corn type, addition of phytase, or phosphorus level on feed conversion at any age. No significant interactions among or between main effects were observed at any age.

Tibia ash: Tibia ash content of the birds fed the experimental diets is shown in Table 5. Male turkeys fed diets with HAP corn had significantly higher tibia ash content at 4, 8, and 12 wk of age than those fed diets

Table 6: Published recommendations for calcium and phosphorus in diets for turkey poults

Year	Author(s)	Age(wk)	Sex[a]	Ca% or ratio	Total P %	Nonphytate[b] P %
1944	Hammond *et al.*	0-8	SR		0.6	
1945	Evans and Brant	0-8	SR	2.0	1.0	
1945	Fritz *et al.*	0-6	SR	2-2.5	1.0	
1948	Motzok and Slinger	0-5	M-F	2.0	1.0	
1956	Creech *et al.*	0-4	SR		0.8	
1960	Sullivan	8-20	M	1.55	0.85	0.50
			F	1.55	0.75	0.40
1961	Nelson *et al.*	8-24	M	0.8	0.8	
			F	0.6	0.6	
			M	0.5	0.5	
			F	0.5	0.5	
1961	Waibel *et al.*	8-14	SR	1.24	0.75	0.50
		14-20		0.89	0.58	0.35
		20-24		0.62	0.48	0.24
1961	Wilcox *et al.*	8-20	M		0.8	
		8-20	F		0.6	
1961	Pensack and White-Stevens	0-4	M-F	0.8-1.2	0.8	
1962	Formica *et al.*	8-mkt	SR	0.83	0.56	0.25
1962	Sullivan	8-20	M-F	0.7	0.7	
1962	Day and Dilworth	9-16	M-F	1:1 to 2:1	0.60	0.33
		17-24			0.45	0.21
1962	Jones *et al.*	8-23	SR			0.6-0.7
1963	Nelson *et al.*	8-20	M	0.60	0.60	
1963	Sullivan and Kingan	0-6	SR	1.1-1.4	0.8	0.50
1968	Neagle *et al.*	0-4	M	1.2	0.8	
1977	Choi and Harms	0-3	SR	2:1 Ca:Pi		0.74
1986	Bailey *et al.*	0-1	M			0.75
		0-3	M			0.55
1992	Sanders *et al.*	10-26 d	M	1.25	1.0	0.76
1994	NRC	0-4	M	1.2		0.6
		4-8	M	1.0		0.5
		8-12	M	0.85		0.42
		12-16	M	0.75		0.38
		16-20	M	0.65		0.32
		20-24	M	0.55		0.28

[a]M = Male; F = Female; M-F = Sexes identified but no difference indicated in requirements between sexes; SR = Straight run. May have been weighed separately but no indications given. [b]May have been identified as available, inorganic, or nonphytate by various authors.

with YDC, and were numerically higher at 16 and 20 wk. The addition of 1000 U/kg of phytase resulted in significant improvements in tibia ash at every age. Reduction in dietary nonphytate phosphorus levels below NRC (1994) recommendations generally did not impair tibia ash content until reduced to 0.15% below NRC recommendations. This resulted in a significant reduction at 4 wks of age, and was lower at other ages. At 12 wk of age, tibia ash of those fed – 0.15% nonphytate phosphorus differed significantly from that of birds fed - 0.05 and – 0.10% nonphytate phosphorus, but not from those fed the NRC recommended levels.

A significant interaction between phytase supplementation and phosphorus level occurred at 4 wk of age. When diets contained no phytase supplementation, birds fed the diets with – 0.15% nonphytate phosphorus had a significant reduction in tibia ash as compared to those fed the NRC recommended levels; however when supplemented with 1000 U/kg phytase the tibia ash of those fed diets with – 0.15% nonphytate phosphorus did not differ from that of birds fed the NRC recommended levels. Although similar trends were observed at other ages, the differences were not statistically significant.

Mussehl and Ackerson (1935) were among the first to indicate needs for calcium and phosphorus by the growing turkey. Since that time, the needs for these two minerals by the turkey have been examined sporadically. A review of published recommendations for various age periods by different authors is shown in Table 6, in comparison to current NRC (1994) recommendations. Considerable variation is shown among or between the various authors, in part because of widely different age periods evaluated and time interval between diet changes. Results of the present study suggest that NRC (1994) recommendations for phosphorus are more than adequate and can be reduced by supplementation with phytase and by reduction in overall phosphorus content. This should aid in reduction of phosphorus runoff by application of turkey litter to crop or pasture lands. The inclusion of HAPC corn had no adverse effects on performance and its use should contribute further to reduction in phosphorus in the excreta.

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