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GARY G. PEARL D.V.M.
Director Technical Services

R.R. #2 Box 298
Bloomington, Illinois 61704
Telephone: 309-829-7744 FAX: 309-829-5147

Evaluation of the Phosphorus Provided by Animal Proteins in the Diet of Broiler Chickens[1]

P. W. WALDROUP[2] and M. H. ADAMS
Poultry Science Department, University of Arkansas, Fayetteville, AR 72701
Phone: (501) 575-2065
FAX: (501) 575-3474

Primary Audience: Nutritionists, Purchasing Agents, Researchers

Summary

This study attempted to determine the biological availability of phosphorus in a chick feeding trial. Researchers compared the phosphorus in six samples of poultry byproduct meal and eleven samples of meat and bone meal to a feed-grade mono-dicalcium phosphate. The samples were analyzed to determine moisture, crude protein, fat, ash, crude fiber, calcium, phosphorus, and amino acid content; metabolizable energy was calculated from proximate composition. Diets had adequate but not excessive amounts of all essential nutrients. "Summit" diets containing 0.47% nonphytate phosphorus (NPP) used each of the animal protein sources or the mono-dicalcium phosphorus as the sole source of supplemental phosphorus; these were then blended with a low-phosphorus (0.12% NPP) basal to provide a range of NPP levels. These data indicate no significant difference in relative biological availability of phosphorus in any of the animal protein sources vs. the feed grade mono-dicalcium phosphorus.

Key words: Animal proteins, availability, bone ash, phosphorus

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Description of Problem

Animal protein supplements such as meat and bone meal and poultry byproduct meal have long been utilized by the poultry industry both for their high quality protein and for their phosphorus content. Results of previous studies have indicated excellent availability of the phosphorus provided by commercial sources of animal proteins [1, 2]. Recently, it has been suggested that the phosphorus contributed by animal protein supplements was less biologically available for chicks and pigs than previously assumed [3, 4, 5]. Since a major reason for utilization of animal protein supplements in diets formulated by linear programming is their phosphorus content, any reduction in phosphorus value seriously affects their utilization in poultry feeds. In addition, because of the continued problems with leg disorders in broilers and turkeys, any reduction in the phosphorus provided by animal protein sources may further curtail usage of these supplements.

This study was conducted to evaluate the phosphorus content of samples of animal proteins provided by the rendering industry under conditions analogous to the usage of these products in the poultry industry.

MATERIALS AND METHODS

Samples of animal protein supplements came from a number of renderers. These included six samples of poultry byproduct meal, three samples of all-beef meat and bone meal, four samples of all-pork meat and bone meal, and four samples of mixed beef and pork meat and bone meal. Table 1 offers a description of the samples and the method of processing. All samples were held at 4°C until mixed into the test diets. Commercially available ground limestone and a feed-grade mono-dicalcium phosphate served as reference standards.

TABLE 1. Description of animal protein samples

SAMPLE	DESCRIPTION
A	Poultry byproduct meal, Duke continous process
B	Poultry byproduct meal with sludge, Stored continous process
C	Poultry byproduct meal with sludge and hatchery waste, Stored continous process
D	Poultry byproduct meal, Stored waste heat low temperature system
E	Poultry byproduct meal, low ash pet food grade, open-market sample
F	Poultry byproduct meal, feed grade, open-market sample
G	All beef meat and bone meal, Duke continous process
H	All pork meat and bone meal, Duke continuous process
I	Mixed species meat and bone meal, Duke continous process
J	Very high bone, low protein meat and bone meal, Duke continous process
K	All beef meat and bone meal, Carver-Greenfield process
L	All pork meat and bone meal, Carver-Greenfield process
M	Mixed species meat and bone meal, Carver-Greenfield process
N	All beef meat and bone meal, Stord continous process
O	All pork meat and bone meal, Stord continous process
P	Mixed species meat and bone meal, Stord continous process
Q	All pork meat and bone meal, IBP-Coagulator, Atlas dryer

Proximate analysis (moisture, crude protein, fat, ash, and crude fiber) was conducted by a commercial analytical laboratory. These values were used to calculate the metabolizable energy of the samples using appropriate prediction equations [6]. Calcium, phosphorus, and sodium content of the animal protein samples, ground limestone, mono-dicalcium phosphate, corn, and soybean meal were determined by atomic emission spectroscopy [7] after sample preparation following method 968.08 of AOAC [8]. For animal protein samples and mono-dicalcium phosphate, nonphytate phosphorus values were assumed to be the same as total phosphorus values. For corn and soybean meal, total and nonphytate phosphorus values reported by NRC [6] were used for formulation. The amino acid content of corn, soybean meal, and the animal protein samples was determined by a commercial laboratory using ion-exchange chromatography. The nutrient contents of the various animal protein samples appear in Table 2 (poultry byproduct samples) and in Table 3 (meat and bone samples).

Considerable variation in nutrient content was observed among the samples. For example, crude protein ranged between 45.5 and 69.18%; calcium ranged from 2.58 to 9.76%; phosphorus ranged between 1.71 and 4.57%. It is important in conducting phosphorus assay trials using animal protein supplements that nutrient deficiencies or excesses do not occur that may inhibit utilization of the phosphorus from the test sources. For example, recent work by Skinner *et al.* [9] indicated that high levels of amino acids may interfere with bone calcification in broilers. Inclusion of the various products in test diets at a fixed rate could result in severe imbalances among various nutrients. Therefore, poultry received diets using variable amounts of the different animal protein sources to provide adequate but not excessive levels of essential nutrients.

Using the determined nutrient values, "summit" diets incorporated animal protein supplements as the sole source of supplemental phosphorus in diets for broiler chicks, providing 0.47% nonphytate phosphorus and 0.92% calcium. Actual amounts of the animal protein sources used ranged from 7.89 to

TABLE 2. Nutrient composition of samples of poultry byproduct meal

NUTRIENT	A	B	C	D	E	F
ME, kcal/kg[A]	3239	2833	2609	3005	3061	2672
Dry matter, %	93.05	95.34	95.98	94.86	93.98	92.90
Crude protein, %	62.86	65.93	57.66	68.48	69.18	53.57
Crude fat, %	16.83	10.97	11.03	11.85	11.57	14.00
Crude fiber, %	0.45	0.84	1.13	0.64	0.65	0.50
Ash, %	12.44	15.78	19.59	13.11	11.99	24.87
Calcium, %	2.78	3.84	7.48	2.81	2.58	6.35
Phosphorus, %	1.78	2.28	1.81	1.81	1.71	3.19
Sodium, %	0.42	0.49	0.40	0.48	0.42	0.32
Arginine, %	4.31	4.43	3.82	4.61	4.74	3.72
Glycine, %	5.93	6.15	5.17	6.51	6.49	6.22
Serine, %	2.43	2.66	2.28	2.57	2.65	1.81
Histidine, %	1.23	1.60	1.30	1.33	1.38	1.03
Isoleucine, %	2.33	2.45	2.12	2.46	2.54	1.67
Leucine, %	4.24	4.71	4.08	4.47	4.64	3.14
Lysine, %	3.71	4.19	3.53	3.90	4.14	2.99
Methionine, %	1.12	1.11	1.01	1.14	1.26	0.91
Cystine, %	0.85	0.80	0.76	0.82	0.84	0.48
Phenylanine, %	2.33	2.61	2.23	2.45	2.56	1.72
Tyrosine, %	1.80	1.89	1.66	1.86	2.04	1.20
Threonine, %	2.28	2.54	2.18	2.41	2.50	1.74
Tryptophan, %	0.54	0.41	0.44	0.53	0.62	0.40
Valine, %	2.92	3.07	2.60	2.99	3.08	1.96
Proline, %	4.14	4.32	3.64	4.51	4.46	4.09

[A]Calculated from proximate composition [6]

23.25%. Amino acids were calculated to meet or exceed 110% of the minimum amino acid recommendations for the male broiler suggested by Thomas *et al.* [10]. A positive control "summit" diet was prepared using the mono-dicalcium phosphate sample. A low phosphorus basal diet (0.12% nonphytate phosphorus and 0.92% calcium) used the same amino acid constraints. To facilitate mixing uniformity for small quantities of feeds, a mixture of 77 parts corn, 15 parts soybean meal, and 8 parts of poultry oil was offered as one of the candidate ingredients. Washed builder's sand was used as an inert ingredient. Composition and calculated nutrient content of the test diets appear in Tables 4 and 5. In only one instance (Sample C, a poultry byproduct meal containing sludge and hatchery waste) did the calcium content of the diet exceed 0.92%. Many of the amino acids were present at minimum recommended levels; few amino acids were in great excess of their recommended amounts.

These diets were then mixed and assayed for crude protein, calcium, and total phosphorus by the methods outlined above and were found to be within expected values. A series of experimental diets was then prepared in which the low phosphorus negative control diet was blended with each of the "summit" diets in ratios of 80/20, 60/40, 40/60, and 20/80 (wt/wt). In a total of ninety-one diets, each contained 0.92% calcium (with the exception of diets utilizing Sample C), with nonphytate phosphorus levels of 0.12 (negative control), 0.19, 0.26, 0.33, 0.40, and 0.47% for each of the animal protein supplements and the mono-dicalcium phosphate. Each of these ninety-

TABLE 3. Nutrient composition of samples of meat and bone meal

NUTRIENT	G	H	I	J	K	L	M	N	O	P	Q
ME, kcal/kg[A]	2481	2859	3349	2387	2607	3325	2981	2679	2549	2806	2795
Dry matter, %	91.51	95.25	94.57	93.83	95.41	93.41	92.28	93.88	90.91	93.25	92.14
Crude protein, %	47.44	50.45	50.66	51.41	50.46	50.40	45.50	51.78	54.24	46.96	55.19
Crude fat, %	11.42	13.91	17.88	10.41	10.85	17.83	16.92	10.88	10.55	14.68	12.41
Crude fiber, %	2.03	0.99	1.31	0.78	3.01	1.40	1.25	1.79	0.73	1.76	0.56
Ash, %	28.61	26.39	20.37	31.05	28.00	19.98	25.47	25.33	25.54	27.07	23.51
Calcium, %	8.31	8.42	5.33	9.76	8.34	5.37	7.85	5.44	7.45	7.13	7.23
Phosphorus, %	4.06	4.23	2.81	4.57	3.98	2.72	3.82	2.65	3.60	3.42	3.71
Sodium, %	0.79	0.56	0.60	0.55	0.71	0.64	0.75	0.56	0.46	0.55	0.44
Arginine, %	3.36	3.42	3.32	3.37	3.41	3.31	3.07	3.63	4.03	3.10	4.03
Glycine, %	6.46	6.62	5.60	6.24	6.19	6.21	5.69	6.68	6.98	5.43	7.23
Serine, %	1.81	1.89	1.84	2.73	1.93	1.76	1.70	2.06	2.23	1.73	2.19
Histidine, %	0.78	0.86	1.21	0.89	0.85	0.91	0.83	0.85	0.89	1.01	0.94
Isoleucine, %	1.24	1.24	1.50	1.29	1.43	1.42	1.32	1.41	1.45	1.40	1.47
Leucine, %	2.86	2.85	3.45	3.21	3.00	2.97	2.80	3.16	3.19	3.13	3.13
Lysine, %	2.39	2.56	2.93	2.24	2.52	2.69	2.38	2.61	2.69	2.75	2.76
Methionine, %	0.54	0.69	0.70	0.55	0.62	0.65	0.57	0.62	0.65	0.69	0.68
Cystine, %	0.54	0.41	0.55	0.89	0.55	0.53	0.52	0.74	1.10	0.43	0.76
Phenylanine, %	1.53	1.56	1.84	1.83	1.61	1.62	1.52	1.66	1.65	1.67	1.68
Tyrosine, %	0.92	1.03	0.16	1.08	1.08	1.08	0.98	1.12	1.17	1.07	1.14
Threonine, %	1.46	1.53	1.66	1.73	1.60	1.51	1.42	1.63	1.71	1.56	1.69
Tryptophan, %	0.23	0.28	0.44	0.28	0.33	0.35	0.30	0.30	0.31	0.33	0.30
Valine, %	1.81	1.71	2.25	2.12	1.92	1.95	1.80	1.96	2.00	2.01	2.19
Proline, %	4.19	4.43	3.81	4.65	4.11	4.16	3.77	4.40	8.00	3.60	4.94

[A]Calculated from proximate composition [6]

one feeds was then sampled for calcium and total phosphorus content by the method indicated above and was found to be in agreement with calculated values.

Each of the ninety-one diets was then fed to two replicate pens of six male chicks of a commercial broiler strain [11] in two similar experiments. There was no trial by treatment interaction, so data from the two experiments was combined resulting in four replicate pens per treatment. Chicks were maintained in electrically heated battery brooders with raised wire floors [12]. Chicks were fed from day-old to 21 days on the test diets, with body weight gain and feed consumption determined. At the conclusion of the study all surviving chicks were killed by CO_2 inhalation. The right tibiae were removed, cleaned of adhering tissue, dried, and extracted as described by AOAC [8]. All tibiae from individual pens were pooled and ashed at 600°C.

Nonphytate phosphorus consumption served as the independent variable based on feed consumption data. Tibia ash was regressed upon nonphytate phosphorus consumption for each of the test sources and the mono-dicalcium phosphate, which served as the reference standard. For each source, a two-slope nonlinear regression model was performed to determine the inflection point [13]. The slope of the line below the inflection point was then determined and a comparison made between the slope of the individual animal protein sources and the mono-dicalcium phosphate source. Similar comparisons were made using the combined poultry byproduct meal samples and the combined meat and bone meal samples vs. the mono-dicalcium phosphate source.

TABLE 4. Composition and calculated nutrient content of control diets and summit diets containing poultry byproduct meal

INGREDIENT	NEGATIVE CONTROL	POSITIVE CONTROL	A	B	C	D	E	F
Yellow corn	10.63	2.29	62.86	40.08	34.35	56.48	65.63	29.86
Soybean meal	27.95	27.03	12.58	15.94	11.63	12.05	9.06	20.50
Corn/soy/fat mix[A]	57.94	66.32	0.00	25.78	31.59	8.18	0.00	36.65
Salt	0.49	0.49	0.27	0.29	0.29	0.25	0.26	0.41
Limestone	2.11	1.33	0.67	0.58	0.00	0.69	0.74	0.29
DL-Methionine	0.23	0.24	0.10	0.13	0.12	0.11	0.09	0.21
Lysine HCl	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.01
Vitamin premix[B]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Trace mineral mix[C]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Mono-dicalcium phosphate	0.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00
Animal protein source	0.00	0.00	22.19	16.60	21.42	21.64	23.25	11.47
Washed sand	0.00	0.00	0.73	0.00	0.00	0.00	0.37	0.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CALCULATED ANALYSIS[D]								
ME, kcal/kg	3135	3135	3135	3135	3135	3135	3135	3135
Crude protein, %	22.29	22.28	25.33	25.52	25.18	26.52	26.02	23.56
Calcium, %	**0.93**	**0.93**	**0.93**	**0.93**	1.66	**0.93**	**0.93**	**0.93**
Total phosphorus, %	0.38	0.73	0.65	0.67	0.65	0.65	0.64	0.69
Nonphytate phosphorus, %	0.12	**0.47**	**0.47**	**0.47**	**0.47**	**0.47**	**0.47**	**0.47**
Arginine, %	1.49	1.49	1.63	1.65	1.61	1.70	1.67	1.55
Lysine, %	**1.27**	**1.27**	1.36	1.44	1.39	1.40	1.40	**1.27**
Methionine, %	0.58	0.58	0.55	0.56	0.55	0.55	0.56	0.59
TSAA, %	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**
Threonine, %	0.85	0.85	0.92	0.97	0.94	0.95	0.94	0.85
Tryptophan, %	0.30	0.31	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	0.27
Valine, %	**1.04**	**1.04**	1.18	1.19	1.15	1.19	1.18	**1.04**

[A]Consists of seventy-seven parts corn, fifteen parts soybean meal, and eight parts poultry oil

[B]Provides per kg of diet: vitamin A, 9,900 IU; cholecalciferol, 3,300 ICU; vitamin E, 13 IU; vitamin B, 0.013 mg; riboflavin, 6.6 mg; niacin, 66 mg; d-pantothenic acid, 16.5 mg; choline, 660 mg; menadione, 1.1 mg; folacin, 1.1 mg; thiamin, 1.1 mg, pyridoxine, 3.3 mg; d-biotin, 0.11 mg; Se, 0.20 mg; ethoxyquin, 125 mg.

[C]Provides per kg of diet: Mn ($MnSO_4.H_2O$), 100 mg; Zn ($ZnSO_4.7H_2O$), 100 mg; Fe ($FeSO_4.7H_2O$), 50 mg; Cu ($CuSO_4.5H_2O$), 10 mg; I ($Ca(IO_3)_2.H_2O$), 1 mg.

[D]Figures in bold are at minimum levels.

TABLE 5. Composition of summit diets containing various sources of meat and bone meal

INGREDIENT	G	H	I	J	K	L	M	N	O	P	Q
Yellow corn	29.62	29.77	53.58	27.68	29.10	50.42	35.16	31.90	28.40	35.01	35.52
Soybean meal	23.47	24.34	21.74	22.36	22.57	22.35	23.93	18.69	21.15	21.70	21.54
Corn/soy/fat mix[A]	36.58	35.88	9.96	40.57	37.80	12.20	30.00	34.05	38.91	31.19	31.48
Salt	0.32	0.38	0.30	0.39	0.34	0.28	0.32	0.30	0.38	0.35	0.39
Limestone	0.25	0.30	0.38	0.17	0.20	0.30	0.23	0.23	0.23	0.21	0.34
DL-Methionine	0.24	0.23	0.23	0.22	0.23	0.23	0.23	0.21	0.18	0.24	0.22
Lysine HCl	0.06	0.03	0.05	0.12	0.07	0.04	0.07	0.06	0.06	0.05	0.08
Vitamin premix[B]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Trace mineral mix[C]	8.86	8.47	13.16	7.89	9.09	13.58	9.46	13.96	10.09	10.65	9.83
Animal protein source	8.86	8.47	13.16	7.89	9.09	13.58	9.46	13.96	10.09	10.65	9.83
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CALCULATED ANALYSIS[D]											
ME, kcal/kg	3135	3135	3135	3135	3135	3135	3135	3135	3135	3135	3135
Crude protein, %	23.07	23.44	23.09	22.82	23.15	23.59	22.95	23.66	23.42	22.74	23.19
Calcium, %	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Total phosphorus, %	0.70	0.70	0.69	0.70	0.70	0.69	0.70	0.68	0.70	0.69	0.70
Nonphytate phosphorus, %	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Arginine, %	1.53	1.54	1.48	1.48	1.51	1.52	1.50	1.56	1.57	1.47	1.54
Lysine, %	**1.27**	**1.27**	**1.27**	**1.27**	**1.27**	**1.27**	**1.27**	**1.27**	**1.27**	**1.27**	**1.27**
Methionine, %	0.58	0.59	0.59	0.56	0.58	0.59	0.58	0.56	**0.53**	0.60	0.57
TSAA, %	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**	**0.94**
Threonine, %	0.84	0.85	**0.83**	0.84	0.84	**0.83**	0.84	0.84	0.85	**0.83**	**0.83**
Tryptophan, %	0.27	0.28	0.27	0.27	0.27	0.27	0.27	**0.25**	0.27	0.27	0.26
Valine, %	**1.04**	**1.04**	1.06	**1.04**	**1.04**	**1.04**	**1.04**	**1.04**	**1.04**	**1.04**	**1.04**

[A]Consists of seventy-seven parts corn, fifteen parts soybean meal, and eight parts poultry oil

[B]Provides per kg of diet: vitamin A, 9,900 IU; cholecalciferol, 3,300 ICU; vitamin E, 13 IU; vitamin B_{12}, 0.013 mg; riboflavin, 6.6 mg; d-pantothenic acid, 16.5 mg; choline, 660 mg; menadione, 1.1 mg; folacin, 1.1 mg; thiamin, 1.1 mg; pyridozine, 3.3 mg; d-biotin, 0.11 mg; Se, 0.20 mg; ethoxyquin, 125 mg.

[C]Provides per kg of diet: Mn ($MnSO_4.H_2O$), 100 mg; Zn ($ZnSO_4.7H_2O$), 100 mg; Fe ($FeSO_4.7H_2O$), 50 mg; Cu ($CuSO_4.5H_2O$), 10 mg; I ($Ca(IO_3)_2.H_2O$), 1 mg.

[D]Figures in bold are at minimum levels.

Results and Discussion

Table 6 shows the slopes of the lines of tibia ash regressed against nonphytate phosphorus consumption for the individual animal protein sources. In no instance was there any significant difference in slope of the response line between individual animal protein sources and the reference standard mono-dicalcium phosphate; no difference between the combined poultry byproduct meal or combined meat and bone meal samples vs. the reference standard mono-dicalcium phosphate appeared either. Figure 1 reflects tibia ash values for the poultry byproduct meal samples vs. the reference standard mono-dicalcium phosphate. Tibia ash values for the meat and bone meal samples vs. the mono-dicalcium phosphate reference standard are shown in Figure 2. Body weight gain and feed utilization of chicks fed the animal protein supplements did not differ significantly from that of chicks fed the mono-dicalcium supplements (Table 7).

TABLE 6. Comparison of slopes of regression of tibia ash against nonphytate phosphorus intake for individual animal protein sources and combined samples vs. monodicalcium phosphate reference standard

SAMPLE	SLOPE	SEM	PROBABILITY >F
A	5.27	0.12	0.06
B	5.00	0.89	0.07
C	2.92	0.39	0.53
D	5.85	0.25	0.16
E	3.72	0.40	0.37
F	3.14	0.37	0.83
G	5.61	0.12	0.20
H	2.44	0.38	0.12
I	3.25	0.37	0.98
J	4.75	0.81	0.09
K	3.43	0.34	0.71
L	5.48	0.23	0.17
M	3.19	0.37	0.91
N	3.13	0.37	0.81
O	5.07	0.11	0.11
P	2.67	0.33	0.23
Q	2.88	0.38	0.48
All poultry	3.345	0.12	0.84
All meat and bone	3.246	0.36	0.59
Mono-dicalcium phosphate	3.326	0.19	-

Waldroup *et al.* [2] reported that the relative biological availability of phosphorus from blended samples of fish meal, poultry byproduct meal, and meat and bone meal were 102, 101, and 102%, respectively (compared to monosodium and dicalcium phosphate). These samples came from industry sources and were blended prior to assay. Spandorf and Leong [1] reported that the biological availability of the phosphorus in twelve menhaden fish meals averaged 99% and ranged from 95 to 103% of the values obtained with corresponding levels from dicalcium phosphate. Robbins *et al.* [14] reported that the bioavailability of phosphorus from raw crushed poultry bones (residual backs, necks, and ribs from the deboning process) did not differ from the phosphorus availability of monobasic potassium phosphate. Results of the present studies agree with these reports.

Recent studies by Orban and Roland [3] suggest that the phosphorus from different bone meal sources was not utilized as well as that from dicalcium phosphate for bone development of broilers. These authors concluded that a safety margin of 5 to 10% should be used in the amount of phosphorus from organic sources in broiler diets.

However, there are several aspects of this study that cast doubt upon interpretation of the results. First, preparation of the "bone meal" samples began with boiling them in water for 30 min and then grinding them. Whether this method of preparation subjects the bone to the same type of cooking as experienced in a normal rendering process is questionable. Secondly, the various sources were all fed at one level of phosphorus, eliminating the possibility of comparison by slope-ratio assay, long a standard measure of determining relative biological availability. The test diets all were calculated to provide 0.45% available phosphorus, a level that should more than meet the needs for growth and feed utilization. However, the authors noted significant differences in growth rate or feed utilization among broilers fed the test bone meals vs. those receiving the dicalcium phosphorus control.

This finding does not agree with the majority of studies related to phosphorus requirement of chickens. These studies indicate that

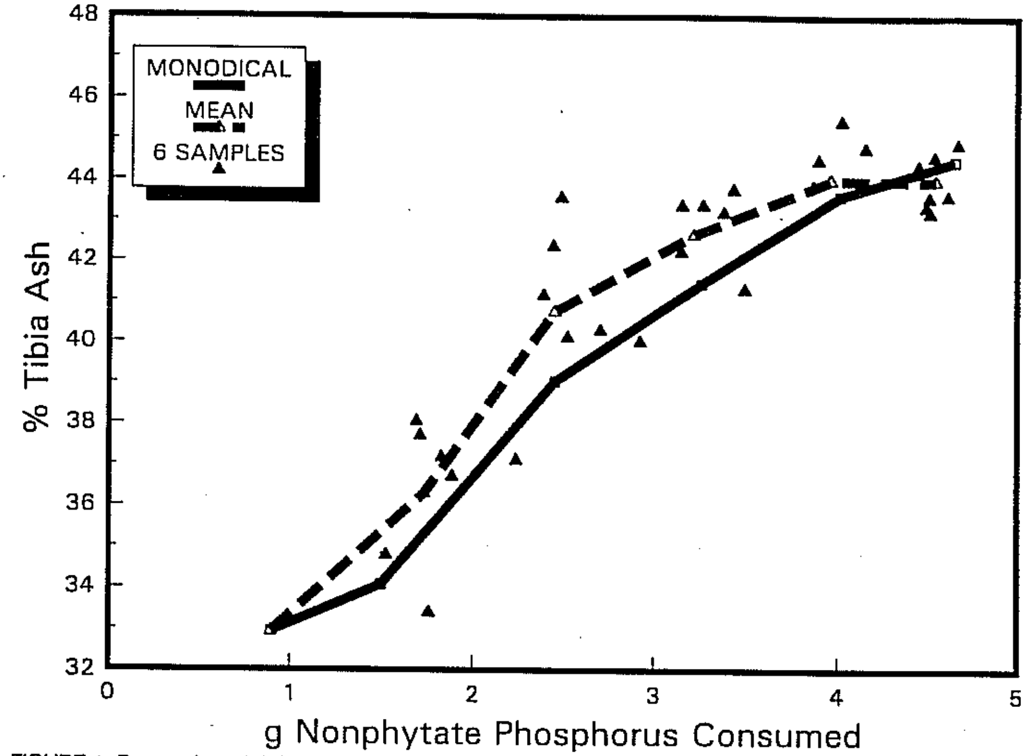

FIGURE 1. Regression of tibia ash compared to nonphytate phosphorus intake of chicks fed various diets of poultry byproduct meal and mono-dicalicum phosphate

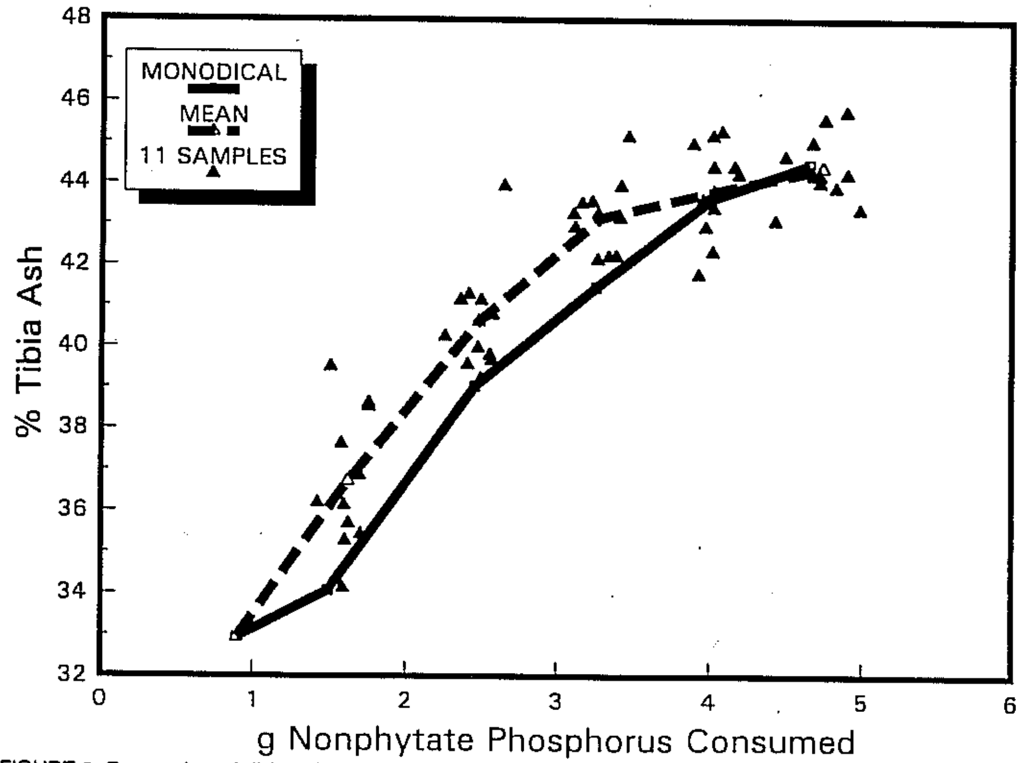

FIGURE 2. Regression of tibia ash compared to nonphytate phosphorus intake of chicks fed various diets of meat and bone meal and mono-dicalcium phosphate

growth rate and feed utilization are poor indicators of phosphorus sufficiency, especially at levels approaching the requirement for maximum bone calcification [15, 16, 17, 18] and suggest that some other factor(s) may have been involved that might have influenced bone growth and development. Orban and Roland commented upon the fact that much of the bone was in the form of large chips, which may well have impacted upon how well the animals digested the bone [15]. Parallel studies in swine [4, 5] suggested that the phosphorus in meat and bone meal was 64 to 72% available; however, Cromwell [19] suggested that this finding might have resulted from the presence of large particles of bone in the sample.

One of the characteristics of animal protein supplements is their variability, and a good quality control program should be able to monitor variations in content and adjust the nutrient matrix accordingly. However, a reduction in assigned phosphorus availability relative to feed-grade phosphorus sources does not appear warranted, based upon the results of this study.

TABLE 7. Influence of phosphorus provided by various animal protein sources on body weight and feed utilization by broilers

BASAL: SUMMIT RATIO[A]	NONPHYTATE PHOSPHORUS	21-DAY BODY WEIGHT				0 to 21-DAY FEED UTILIAZATION			
		Mono-diacalcium phosphate	Poultry byproduct meals[B]	Meat and bone meals[C]	Mean	Mono-dicalcium phosphorus	Poultry byproduct meals	Meat and bone meals	Mean
	(%)	g				g feed/g gain			
100/0	0.12	502	502	502	502[d]	1.431	1.431	1.431	1.431
80/20	0.19	541	571	598	570[c]	1.427	1.469	1.500	1.465
60/40	0.26	638	642	651	644[b]	1.463	1.475	1.445	1.461
40/60	0.33	695	670	667	677[a]	1.414	1.482	1.458	1.451
20/80	0.40	667	686	661	671[a]	1.502	1.467	1.501	1.490
0/100	0.47	684	675	669	676[a]	1.448	1.497	1.451	1.465
Mean		621	624	625	623	1.448	1.470	1.64	1.460
Pooled SEM					8.5				0.025

[A]Ratio of basal diet and appropriate summit diet

[B]Mean of six samples of poultry byproduct meal

[C]Mean of eleven samples of meat and bone meal

[a-d]Means in column with same superscript do not differ significantly ($P \leq .05$).

Conclusions and Applications

1. Six samples of poultry byproduct meal and eleven samples of meat and bone meal were obtained from industry sources and exhaustively analyzed for nutrient content.
2. These animal protein byproduct meals were incorporated into nutritionally balanced broiler diets to provide graded levels of phosphorus. Poultry received one of those diets from day-old to 21 days of age.
3. Live performance and tibia ash of birds fed the animal protein byproduct meals were compared to that of birds fed diets with a feed grade mono-dicalcium phosphate.
4. No significant difference in live performance or tibia ash content was observed among birds fed the various animal protein byproduct meals and those fed the feed grade mono-dicalcium phosphate.
5. A reduction in assigned phosphorus availability of animal protein byproduct meals relative to feed-grade phosphorus sources does not appear warranted.

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[2] To whom correspondence should be addressed