Poultry

Improving Phytate Phosphorus Utilization by Poultry With Live Yeast Culture

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Story in Brief

Two feeding trials were conducted to determine the effect of a live yeast culture on phosphorus utilization in rations for growing chickens up to eight weeks of age. The total available phosphorus level of the grower ration was calculated first, and the amount of supplemental inorganic phosphorus needed to bring the total available dietary phosphorus level up to NRC Requirements was determined by difference. The amount of inorganic phosphorus supplement required to provide this amount was designated as 100 percent. The five other supplemental levels which were used were 0, 20, 40, 60, and 80 percent of this amount, respectively. These six dietary phosphorus levels were fed in one series of rations which contained a live yeast culture, and in another series of rations which did not.

Growth rate, units of feed per unit of gain, percent bone ash, percent bone calcium, and percent bone phosphorus were used to measure the efficiency with which the phosphorus was utilized. The live yeast culture produced a statistically significant increase in growth rate at inorganic phosphorus supplement levels of 0 and 20 percent of the amount required to meet NRC Requirements. Values for bone ash, bone calcium, and bone phosphorus for the growing chickens fed rations supplemented with live yeast culture, and those fed unsupplemented rations did not show statistically significant differences at these inorganic phosphorus supplement levels. However, substantial differences were evident and higher values were obtained with the growing chickens fed the live yeast culture.

Apparently the live yeast culture is bringing about a more efficient utilization of dietary phosphorus through the synthesis in the digestive tract of phytase which is hydrolyzing the phytate phosphorus. Based upon these data, it can be recommended that inorganic phosphorus supplement levels in a soybean oil meal—corn ration may be reduced by some 40 to 60 percent through the use of a live yeast culture without adversely affecting growth rate, efficiency of feed utilization, or bone ash percentage.

Introduction

Phytate phosphorus, the calcium-magnesium-potassium salt of phytic acid, is the organic form in which a major part of the phosphorus in plants is found. The phosphorus in alfalfa leaf meal, the cereal grains, soybean oil meal, cottonseed meal, and other feed ingredients manufactured from plants is present in this form.

In order for phytate phosphorus to be absorbed through the intestinal wall and utilized in bone formation or other physiological functions, it first must be changed by a chemical reaction into inorganic phosphate. This chemical reaction which is called hydrolysis is brought about by the action of the enzyme, phytase.

Phytase may be present in feed ingredients or can be produced by microorganisms in the digestive tract of domestic animals. If the concentration of phytase from these sources is sufficient, large quantities of phytate phosphorus will be hydrolyzed and the phosphorus utilized efficiently. It is possible also to hydrolyze the phytate phosphorus in plant feed ingredients during the manufacturing process through the use of molds which produce phytase.

Ruminants can utilize phytase phosphorus effectively since the microorganisms in the rumen produce adequate quantities of phytase. Thus, in this way, phytate phosphorus makes a major contribution to the readily utilizable dietary phosphorus in practical rations for beef cattle, dairy cattle, and sheep through the synthesis of phytase in the intestinal tract. On the other hand, simple stomach animals like swine, and poultry are not capable of producing phytase by this means, and for this reason, utilize phytate phosphorus very poorly or not at all. However, if phytase could be supplied by the addition of a feed ingredient with a high phytase content or by the addition of a feed ingredient which would promote the production of phytase, greater quantities of phytate phosphorus might be utilized.

During the current shortage of inorganic phosphorus supplements, feeding trials were initiated with growing chickens to determine if live yeast culture at a ration level of 2.5 percent would substantially increase phytate phosphorus utilization through the production of phytase in the intestinal tract. If this could be accomplished, the amount of supplemental inorganic phosphorus in a ration could be materially reduced without adversely affecting growth rate or bone formation. In addition, available supplies of inorganic phosphorus supplements would be conserved, and ration cost could be reduced.

Materials and Methods

Phytase Activity Invitro —

Whole corn at a normal moisture level was ground to pass a 1.5 millimeter screen in a Raymond Mill. Ninety parts of the ground corn were mixed with 10 parts of a live yeast culture and the whole blended for 2 hours in a Patterson-Kelly V-mixer to insure a uniform composition. An intensifier bar was used intermittently to insure mixing. Samples were taken for an analysis to determine total phosphorus and phytate bound phosphorus.

A fermentation mixture was prepared as a 20 percent solids slurry and adjusted to a pH of 5.0 with hydrochloric acid. Portions were added to sterile jars and incubated at 100° F for the fermentation phase of the reaction. Samples were taken at fermentation time intervals of 0, 0.5, 1.0, 4.0, and 24 hours and analyzed for phytate phosphorus.

Feeding Trial I —

Single Comb White Leghorn cockerels were used in Feeding Trial I. They were obtained when they were day-old and divided into 24 lots with 10 cockerels in each lot. Each lot was housed in a section of an electric battery brooder. Feed and water were provided *ad libitum*.

Each of the 12 exprimental rations as listed in Table 1 were fed to duplicate lots during a 3-week feeding period. The experimental rations were formulated to contain 6 graded levels of an inorganic phosphorus supplement (calcium 17.66 percent; phosphorus 18.25 percent by analysis) which supplied 0, 20, 40, 60, 80 and 100 percent, respectively, of the inorganic phosphorus supplement required to increase total available dietary phosphorus to a level equivalent to NRC Requirements. One series of 6 experimental rations formulated in this way was supplemented with 2.5 percent of a live yeast culture, and another series of 6 experimental rations had the live yeast culture replaced with ground yellow corn.

Individual body weights were taken at weekly intervals and feed consumption by lots was determined at the same time intervals. Tibia bones were taken at the end of the 3-week feeding period, and analyzed for percent bone ash, calcium, and phosphorus.

Feeding Trial II

Cornish X White Rock broilers were used in Feeding Trial II. At day-old they were distributed at random into 24 floor pens with 10 males and 10 females in each pen. Feed and water were provided *ad libitum*.

The 12 experimental rations as listed in Table 1 were fed to duplicate pens of broilers during the first 4 weeks of an 8-week feeding period. These are the same rations which were fed in Feeding Trial I during the

Table 1 - Experimental Rations

Ingredients	Ration Number (Percent)					
	1	2	3	4	5	6
Tallow (Feed Grade)	3.0	3.0	3.0	3.0	3.0	3.0
Ground Yellow Corn	49.12	49.12	49.12	49.12	49.12	49.12
Soybean Oil Meal (44%)	40.5	40.5	40.5	40.5	40.5	40.5
Live Yeast Culture[1]	2.5	2.5	2.5	2.5	2.5	2.5
dl Methionine	0.08	0.08	0.08	0.08	0.08	0.08
Inorganic Phosphorus Supplement (17.66% Ca-18.25% P)	0.00	0.55	1.09	1.64	2.18	2.73
Calcium Carbonate	2.43	2.26	1.99	1.71	1.44	1.16
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin Mineral Concentrate	0.5	0.5	0.5	0.5	0.5	0.5
Sand	1.37	0.99	0.72	0.45	0.18	0.00

Ingredients	Ration Number					
	7	8	9	10	11	12
Tallow (Feed Grade)	3.0	3.0	3.0	3.0	3.0	3.0
Ground Yellow Corn	51.62	51.62	51.62	51.62	51.62	51.53
Soybean Oil Meal (44%)	40.5	40.5	40.5	40.5	40.5	40.5
dl Methionine	0.08	0.08	0.08	0.08	0.08	0.08
Inorganic Phosphorus Supplement (17.66% Ca-18.25% P)	0.00	0.55	1.09	1.64	2.18	2.73
Calcium Carbonate	2.43	2.26	1.99	1.71	1.44	1.16
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin Mineral Concentrate	0.5	0.5	0.5	0.5	0.5	0.5
Sand	1.37	0.99	0.72	0.45	0.18	0.00

By Chemical Analysis Crude protein of the 12 rations ranged from 22.00 percent to 24.75 percent with an average of 23.37 percent. Total calcium of the 12 rations ranged from 0.82 percent to 1.28 percent with an average of 1.05 percent. Total phosphorus was 0.47, 0.57, 0.64, 0.73, 0.80, and 0.93 percent for Rations 1, 2, 3, 4, 5, and 6; and 7, 8, 9, 10, 11, and 12, respectively.

By Calculation: Comparable available phosphorus levels were 0.14, 0.24, 0.34, 0.44, 0.54, and 0.64, respectively.

[1] Manufactured by Diamond V Mills, Cedar Rapids, Iowa.

entire 3-week feeding period. These 12 experimental rations were modified in energy content by increasing the calorie to protein ratio at the beginning of the fifth and seventh weeks of the growing period in order to meet changing energy and protein intake requirements.

Individual body weights were taken at weekly intervals and feed consumption was recorded by pens at the same time intervals. Tibia bones were taken at the end of the fourth and eighth weeks of the growing period.

Appropriate statistical analyses were made on the data from both Feeding Trial I, and Feeding Trial II. The following responses were involved in these analyses: body weight, units of feed per unit of gain, percent of bone ash, percent bone calcium, and percent bone phosphorus.

Results and Discussion

Phytase Activity Invitro —

The rate at which the phytate phosphorus in the fermentation mixture was hydrolyzed by the live yeast culture is shown in Table 2. These data would indicate that 75 to 80 percent of the phytate phosphorus was released in four hours under the conditions of this test. All of the phytate phosphorus was released at some point between 4 and 24 hours after fermentation was initiated. Apparently a substantial amount of phytase was being produced by the live yeast culture and this enzyme was effective in hydrolyzing the phytate phosphorus present in the yellow corn. It is logical to conclude that this action might take place in a similar manner in the intestinal tract of growing chickens if the live yeast culture were included in the ration.

Feeding Trial 1 —

Body weight and feed conversion data for Feeding Trial 1 are presented in Table 3. There are statistically significant differences in average body weight in favor of the growing chickens fed the rations supplemented with the live yeast culture. The greatest growth response was made with inorganic phosphorus supplement levels of 0 and 20 percent of the required amount. However, there seemed to be some response in-so-far as growth rate was concerned irrespective of inorganic phosphorus supplement level. Growth rate was not fully compensated for at the lower phosphorus supplement levels since there are statistically significant differences due to inorganic phosphorus supplement level.

This advantage appears to increase from week to week. This may be due to the time lag required for the live yeast culture to establish itself

Table 2 - Rate of Phytate Hydrolysis by Live Yeast Culture Invitro[1]

Fermentation Time	Phytate Phosphorus in Fermentation Mixture by Iron Analysis	by Phosphorus Analysis
0.0 Hours	0.34 mg/gm	0.38 mg/gm
0.5 Hours	0.31	0.39
1.0 Hours	0.33	0.31
4.0 Hours	0.13	0.08
24.0 Hours	0.00	0.00

By Chemical Analysis — Total Phosphorus in Dry Mixture ....3.25 mg/gm
Total Phosphorus in Fermentation Mixture
(20 percent solids)........ 0.70 mg/gm
Total Phytate Bound Phosphorus in
Fermentation Mixture........ 0.38 mg/gm

[1] Test conducted by Bedford Laboratories, Cedar Rapids, Iowa under the Supervision of Charlie Stone, Diamond V Mills, Cedar Rapids, Iowa.

Table 3 - Data Feeding Trial 1

Experimental Ration Number	Inorganic Phosphorus Supplement Level (Percent Required Amount)	Live Yeast Culture (Percent of Ration)	WEEKS 1 Body Wt (gm)	1 Units Feed / Unit Gain	2 Body Wt (gm)	2 Units Feed / Unit Gain	3 Body Wt (gm)	3 Units Feed / Unit Gain
1	0	2.5	57	2.48	106	3.28	179	2.13
2	20	2.5	59	2.11	115	2.70	200	2.33
3	40	2.5	63	2.30	135	2.20	237	1.94
4	60	2.5	68	2.27	151	2.46	255	1.81
5	80	2.5	65	2.43	148	2.16	253	1.97
6	100	2.5	65	2.18	142	2.36	242	1.95
7	0	0	58	2.59	111	2.61	165	3.87
8	20	0	60	2.65	117	2.82	200	2.46
9	40	0	61	2.20	128	2.71	223	2.17
10	60	0	69	1.81	147	1.96	251	1.87
11	80	0	65	2.05	144	2.39	247	2.01
12	100	0	66	1.85	140	2.43	243	1.80
		Experimental Ration:						
Difference Between Live Yeast Culture and No Yeast Culture		1 minus 7	−1		−5		+14	
		2 minus 8	−1		−2		0	
		3 minus 9	+2		+7		+14	
		4 minus 10	−1		+4		+ 4	
		5 minus 11	0		+4		+ 6	
		6 minus 12	+1		+2		− 1	

in the intestinal tract. A similar trend can be noted in Feeding Trial 2. There are no statistically significant differences in efficiency of feed conversion in Feeding Trial 1.

A statistical analysis of the bone ash, bone calcium, and bone phosphorus data does not show any statistically significant differences (Table 4.) Nevertheless, there are obvious differences in favor of the growing chickens fed the live yeast culture. This would indicate that phosphorus utilization is being enhanced by the action of the live yeast culture.

Feeding Trial 2 –

Body weight and feed conversion data for Feeding Trial 2 are given in Table 5 for weeks 1 through 4, and in Table 6 for weeks 5 through 8. Results are similar to those obtained in Feeding Trial 1. The trends which were apparent during the 3-week feeding period in Feeding Trial 1 persisted during the entire 8-week feeding period in Feeding Trial 2. Statistically significant differences in average body weight were apparent between the chickens fed the rations supplemented with live yeast culture and those fed the unsupplemented rations. Again this difference was most pronounced at the inorganic phosphorus supplement levels of 0 and 20 percent of the required amount. It continued to widen as the feeding period progressed. There were no real differences in efficiency of feed conversion.

Table 4 - Data Feeding Trial 1 - Bone Ash, Bone Calcium, and Bone Phosphorus

Experimental Ration Number	Inorganic Phosphorus Supplement Level (Percent Required Amount)	Live Yeast Culture (Percent of Ration)	Bone Ash (Percent)	Bone Calcium (Percent)	Bone Phosphorus (Percent)
1	0	2.5	33.44	11.3	5.47
2	20	2.5	39.33	----	----
3	40	2.5	44.12	15.2	7.68
4	60	2.5	44.22	15.5	7.76
5	80	2.5	45.41	16.0	8.07
6	100	2.5	46.36	16.4	8.29
7	0	0	30.70	10.3	5.14
8	20	0	35.99	12.2	6.12
9	40	0	43.84	15.2	7.71
10	60	0	43.97	15.3	7.85
11	80	0	45.53	16.1	8.11
12	100	0	44.33	15.9	7.92

Table 5 - Data Feeding Table 2 - For Weeks One Through Four

Experimental Ration Number	Inorganic Phosphorus Supplement Level (Percent Required Amount)	Live Yeast Culture (Percent of Ration)	WEEKS 1 Body Wt (gm)	1 Units Feed / Unit Gain	2 Body Wt (gm)	2 Units Feed / Unit Gain	3 Body Wt (gm)	3 Units Feed / Unit Gain	4 Body Wt (gm)	4 Units Feed / Unit Gain
1	0	2.5	116	1.20	225	1.43	344	3.07	542	2.00
2	20	2.5	121	1.17	244	1.61	392	2.21	586	2.65
3	40	2.5	118	1.19	251	1.71	403	2.15	585	2.98
4	60	2.5	122	1.26	254	1.70	410	1.79	627	2.56
5	80	2.5	122	1.31	252	1.56	379	2.23	589	2.42
6	100	2.5	124	1.29	265	1.56	417	1.95	645	2.49
7	0	0	108	1.18	207	1.82	318	2.25	485	2.40
8	20	0	113	1.89	231	1.55	364	2.43	591	2.03
9	40	0	120	1.47	257	1.73	409	1.46	586	3.34
10	60	0	125	1.61	264	1.63	407	1.47	624	2.65
11	80	0	117	0.81	252	1.45	398	2.18	614	2.36
12	100	0	124	1.22	267	1.46	409	2.15	616	2.43
		Experimental Ration:								
Difference Between		1 minus 7	+8		+18		+26		+57	
Live Yeast Culture		2 minus 8	+8		+13		+28		− 5	
and No Yeast Culture		3 minus 9	−2		− 6		− 6		− 1	
		4 minus 10	−3		−10		+ 3		+ 3	
		5 minus 11	+5		0		−19		−25	
		6 minus 12	0		− 2		+ 8		+29	