Does Dietary Phytase Supplementation Increase Phosphorus Solubility in Poultry Manure?

Todd J. Applegate, Ph.D. – Dept. of Animal Sciences - Purdue University
Roselina Angel, Ph.D. – Dept. of Animal and Avian Sciences – University of Maryland, College Park

Introduction

Substantial controversy exists around the impact, beyond that of improving seed based phosphorus utilization, of the use of phytase in poultry and swine diets. The controversy is largely related to the possibility that the proportion of water-soluble phosphorus relative to total phosphorus in manure may be increased when phytase is used. The concern is related to the potential for increased run-off or leaching, in the short term, due to the increases in water soluble phosphorus which can cause increases in eutrophication to surface waters. Much of the controversy extends from a report by DeLaune et al. (2001). In that report, runoff during a rainfall simulation from tall fescue field plots fertilized with litter from broilers fed diets with the enzyme, phytase, had greater water soluble phosphorus concentrations.

This report has gleaned considerable attention because of the potential negative implications. It is important though to put this report in the context of other reported work and to explore why this report differs from others.

Contrary to the report of DeLaune et al. (2001), Moore and coworkers had reported in 1998 that there were numerical, but non-significant reductions in both total and soluble phosphorus concentrations in broiler litter when phytase was added to either normal corn or low-phytate corn diets for two flocks. This litter was then applied to fescue test plots at similar application rates (based on weight). Total and water-soluble phosphorus in runoff from the plots on the day of application or 7 days after application were not significantly different between soil fertilized with litters from birds fed normal or low-phytate corn with or without phytase.

Since the report by DeLaune et al. (2001), a number of researchers have looked at this issue of total to water soluble concentrations in litter from poultry fed diets with or without phytase. A summary of these studies is presented in Table 1.

Table 1. Summary of feeding trials and field runoff studies where animals were fed phytase. Direction of arrows indicates if phytase significantly affected manure phosphorus characteristics. Dashes represent non-significant differences between treatments. ND = Not determined

		Soluble phosphorus		Field soluble phosphorus
Reference	Specie	(%)	(% of total P)	(mg P / L)
Moore et al., 1998	Broiler	- - -	- - -	- - -
Saylor et al., 2001	Broiler	↓	- - -	ND
DeLaune et al., 2001	Broiler	↑	↑	↑
Dhandu et al., 2002	Broiler	↓	↑	ND
Thompson et al., 2002	Turkey	- - -	- - -	ND
Newman et al., 2002	Broiler	↓	↓	ND
Maguire et al., 2003	Turkey	↓	↓	↓
Applegate et al., 2003	Broiler	↓	- - -	ND
Miles et al., 2003	Broiler	↓	↓	ND

When comparing reports that touch on this issue, it is important to delve into the research methodologies used. Within those methodologies, there is the answer to why some of the conflicting results exist. This publication seeks to address a number of those factors including:

A) Phosphorus availability for utilization by the animal from both inorganic and organic sources – impact on amount and form of excreted phosphorus
B) Dietary phosphorus concentration fed and consumed versus the animal's requirement – impact on amount and form of excreted phosphorus
C) Phytase activity/efficacy – how much inorganic phosphorus should be removed when phytase is used? What are the consequences of not removing enough phosphorus?
D) Phytase – where is it active in the animal and is it still active in the litter?
E) What other factors, occurring after excreta is voided by the animal, can change solubility of P in litter? (For e.g. excreta storage conditions)

Phosphorus availability for utilization from inorganic and organic sources

Inorganic sources

Before going any further, it is important to clarify terms related to phosphorus levels and availability in inorganic feed ingredients. Most reports published on the availability of phosphorus in inorganic sources use the concept/method of "biological value". Biological value of inorganic sources refers to the relative phosphorus availability, relative to a “standardized” phosphorus source (typically monosodium phosphate), which is usually given a 100% relative biological value. Often these trials are conducted utilizing a) slope response or b) in vitro solubility in water, acid, or ammonium citrate (Axe, 1998). “Biological value”, however, is often confused with “digestibility” or “availability” of that phosphorus source. Most of the literature base typically utilizes the “biological value” approach for determining the relative “value” of an ingredient, but often does not measure the digestibility of the phosphorus source. The few reports that have measured digestibility of phosphorus from inorganic sources have noted that they can range from 87% for mono-calcium phosphate to 60% for defluorinated phosphate (Table 2).

Table 2. Apparent utilization of phosphorus from inorganic sources by broiler chickens.

Reference	Inorganic phosphorus source	Apparent phosphorus retention, %
Van der Klis et al., 1994	Mono-calcium phosphate	87
Van der Klis and Versteegh, 1996	Mono-calcium phosphate	84
Van der Klis and Versteegh, 1996	Mono- / dicalcium phosphate	79
Leske and Coon, 2002	Mono- / dicalcium phosphate	77
Leske and Coon, 2002	Mono- / dicalcium phosphate	80
Leske and Coon, 2002	Mono- / dicalcium phosphate	81
Seo and Coon, 2002	Dicalcium phosphate	60
Seo and Coon, 2002	Defluorinated phosphate	64
Seo and Coon, 2002	Defluorinated phosphate	60

Notably, when most of these studies determined apparent retention of phosphorus from each of the inorganic sources noted above, the majority of studies were within the deficiency range. As such, Leske and Coon noted dramatic reductions in retention from monocalcium phosphate as the phosphorus concentration approached the requirement (98% at half of the requirement to 59% retention at requirement). Waldroup (2002) noted that nearly 50% of excreted phosphorus, therefore, is likely of inorganic origin.

Generally, phosphorus must be in the phosphate form to be absorbed by poultry and swine. As phosphates are heated, pyro- and meta- complexes are formed which greatly reduce the availability of inorganic sources. Other factors which substantially affect inorganic phosphorus source availability include: hydration of source (Gillus et al., 1962; Supplee, 1962), particle size (larger size typically increases availability), and contaminants (complexing with elements such as aluminum can reduce availability).

Organic sources

Actual phosphorus and phytin-phosphorus content in different feed ingredients varies somewhat between different publications (NRC, 1994; Van Der Klis and Versteegh, 1996; Nelson et al., 1968) (Tables 3, 4). Data are still limited (Nelson et al., 1968) as to the variability in of phytin-phosphorus content (Table 4) within an ingredient and how soil and environmental factors may affect this content (Cossa et al., 1997). These researchers found no apparent differences between locations and early, medium and late varieties of corn on the phytin-phosphorus content of the corn. There is also limited information on potential variability in the availability of phosphorus (Van Der Klis and Versteegh, 1996; Cossa et al., 1997) (Table 4) within an ingredient and on how diet manufacturing process may affect this availability (De Goote and Huyghebeart, 1996).

Variability in phytin-phosphorus content in grains and relative bioavailability and digestibility from inorganic phosphorus sources has led to substantial safety margins during realistic diet formulation. For all practical purposes, these over-formulations may have the greatest influence on total and soluble phosphorus content of in excreta and litter.

TABLE 3. P availability from plant and animal sources and feed phosphates measured in three-week old broilers (From [a] Van Der Klis and Versteegh (1996) and [b] Coon and Leske (1998), [c]National Research Council (1994))

Ingredient	TP, g/kg	PP, g/kg	[a]AP (% of TP)	[b]Retainable P % (SD)	[c]nPP, %	[c]nPP, % of TP
Corn	3.0	2.28	29		0.08	28.0
Corn	-	3.96	-	34.9 (11.1)		
SBM (solvent extracted)	7.1	4.33	61		0.22	35.5
SBM	-	2.39	-	30.8 (8.6)		
Wheat	3.4	2.52	48		0.13	35.1
Wheat	-	3.32	-	30.7 (4.5)		
Wheat Middlings	10.8	7.99	36		0.20	17.4
Wheat Middlings	-	11.85	-	29.1 (4.0)		
Meat and Bone Meal	60	-	66			
Fish Meal	22	-	74			
Dicalcium Phosphate	181	-	77			
Monocalcium Phosphate	226	-	84			

[a] Availability based on standardized balance trials. [b] Retainable P based on balance trials. Total phosphorus (TP), available phosphorus (aP), phytate phosphorus (PP), non-phytate phosphorus (nPP).

TABLE 4. PP content of feed ingredients (From *Nelson et al. (1968) and **Cossa et al. (1997))

Ingredient	Number of Samples	PP, % (SD)	PP (% of TP)
*SBM (50% protein)	20	0.37 (0.03)	71
*SBM (44% protein)	3	0.38	58
*Corn	10	0.17 (0.02)	66
**Corn	54	0.27 (0.34)	86
*Corn Gluten Meal	1	0.36	62
*Milo	11	0.21 (0.03)	68
*Wheat	2	0.18	67
*Wheat Middlings	1	0.35	74

Dietary Phosphorus Requirements

Feeding birds well over what they need for productive purposes, may also influence excretion of phosphorus and the form of P in the excreta.

Broilers

Recent research has elucidated substantial differences in the non-phytate P (nPP) requirement of broilers versus those published by the National Research Council (1994). Yan et al. (2001) reported a requirement of 0.33% NPP for Cobb 500 male broilers from three to six wk when tibia ash percent was taken as the criterion. As industry may not typically feed in 3 wk intervals, Angel et al. (2000a,b) conducted a series of experiments to determine the nPP requirements of male Ross 308 broilers in a 4 phase feeding program. The nPP requirements were reported to be between 0.32 and 0.28% nPP (0.80% Ca) in the grower phase (18 to 32 d) based on growth and tibia ash. The nPP requirement in the finisher phase (32 to 42 d) was reported to be between 0.24 and 0.19% nPP (0.70% Ca) and in the withdrawal phase between 0.16 and 0.11% nPP (0.61% Ca; 42 to 49 d of age). When considered together, the nPP requirements for broilers (Angel et al., 2000a,b; Yan et al., 2001) are considerably lower than those published previously (NRC, 1994). In a four-phase feeding program, nPP requirements were reported for Ross 308 males by Angel et al. (2000a,b), Dhandu et al. (2000), and Ling et al. (2000). In these reports, the carry-over effect of previous phases was considered in developing the requirement data, which is not always the case across cited literature. Extrapolation of requirements as reported by these authors can not be done directly with the 3 wk phases as reported by NRC (1994) or with other strains or genders. Other authors, however, have noted that the NRC (1994) nPP requirement is substantially higher than that required for overall performance in 3 wk phases. For example, Waldroup et al. (2000) reported that nPP could be reduced within an age period by 0.075% from 0 to 21, 21 to 42, and 42 to 56 d of age without adverse affects on broiler growth. The dietary reduction of nPP within each age period by 0.075%, however, did significantly reduce tibia ash at all ages. Yan et al. (2001) reported a requirement of 0.332% nPP for Cobb 500 male broilers from 3 to 6 wk of age when tibia ash percent was taken as the criteria.

Turkeys -

In experiments with turkeys, Roberson et al. (2000 a,b) noted that nPP concentrations above NRC (1994) provided no additional benefit in either growth or bone mineralization from 8 to15 weeks of age. However, when nPP concentrations are reduced to 75% of NRC (1994) recommendations from 3 to 17 weeks of age, growth and bone mineralization were impaired. Similar results were observed by Thompson et al. (2002) when toms were fed either industry nPP diets, NRC (1994) diets, or 83% of NRC (1994) diets from 0 to 18 wk of age. No differences were observed in growth between the industry and NRC diets, whereas birds fed the 83% NRC diets had significantly lower tibia mineralization and were substantially lighter.

What is not known is how different strains and genders (hens vs toms) respond to varying nPP concentrations, particularly during different times of the year when known differences in growth rate occur.

Phytase activity – how much inorganic phosphorus should be removed?

Deciding what phosphorus concentration to formulate to is difficult due to a lack of clarity on what the phosphorus requirements are and the amount of phytin-phosphorus liberated with supplemental phytase. In summarizing a number of trials with broilers, Angel et al. (2002) noted a range of values to obtain a 0.1% sparing effect of P from 781 to 1413 U phytase/kg diet for broilers. Most phytase suppliers recommend an average of 0.1% P removal with an inclusion of 500 U/kg. Angel et al. (2002), however, noted an average of 0.065% P spared with 500 U/kg (analyzed) into the diet. In turkeys, the additional P spared appears to be somewhat higher. In summarizing a number of trials with turkeys, the additional P spared when 500 to 600 U phytase / kg diet averaged 0.09% (Angel et al. 2001; Applegate et al., 2002; unpublished research-Applegate et al., 2003).

The difference in the amount of P liberated in research trials with an analyzed 500 to 600 U phytase / kg diet and the 0.1% P that is recommended by the phytase suppliers at the same inclusion rate can easily be explained through product safety margins. As such, most phytases will contain substantial (and frequently variable) safety margins to account for product shelf-life and animal functionality. As such, the safety margins will push the analyzed phytase concentration well into the 781 to 1413 U/kg range where Angel et al. (2002) noted at least 0.1% P spared.

Broiler trials

Applegate et al. (2003) conducted a trial where they reduced P content at different rates for broilers to 49 d of age. For this experiment, dietary nPP was similar to industry formulations and was reduced by 0.1% in all phases when phytase was supplemented to the diets at 600 U/kg (IND+PT diet), whereas in a second diet, birds were fed to their nPP requirement and when phytase was supplemented to the diet, nPP was reduced by 0.1%

in the starter and by 0.06% subsequent phases (REQ+PT diet). When birds were fed more closely to their requirements with these assumed sparing levels when phytase was supplemented, neither bird performance nor bone ash at 49 d of age was significantly affected. These results suggest, therefore, that broiler NPP formulations can be substantially reduced with supplemental phytase and formulation to the bird's requirement (a reduction of 7.73 g P per bird to 49 d and 3.0 kg BW). Additionally, when diets were supplemented with phytase and formulated 0.1% below a 'typical' industry diet (IND+PT), dietary P intake was 2.42 g higher than birds fed REQ+P. The litter coming from the IND+PT birds, however, did not contain significantly higher total or soluble P concentrations in the litter than litter from birds fed REQ+PT diets. Litter from broilers fed an industry nPP diet was significantly higher ($P < 0.05$) in total and water-soluble P (1.11 and 0.22% of DM, respectively) when compared with either diet containing supplemental phytase.

The nPP fed by Applegate et al. (2003) with the REQ+PT diet did not significantly affect bird performance or bone mineralization, thereby validating the four-phase nPP requirements reported for Ross 308 males by Angel et al. (2000a,b), Dhandu et al. (2000), and Ling et al. (2000).

Further validation of the broiler nPP requirements in a four phase feeding program were provided by Dhandu et al. (2002). In their studies, two identical floor-pen trials were conducted with commercial broilers to determine the impact of feeding reduced nPP with or without added phytase and 25OHD3 on litter total and soluble P. Six diets were used: 1) NRC (1994) nPP recommended levels, 2) nPP requirements as reported by Angel et al. (2000 a,b) and Dhandu et al. (2000), 3) diet 2 plus phytase (less 0.064%nPP) 4) diet 2 plus phytase and 25OHD3 (less 0.09% nPP), 5) diet 1 plus phytase (less 0.1%nPP), and 6) 10% less nPP than diet 2 (negative control). Litter from birds fed phytase (diets 3,4 and 5) had lower ($P < 0.05$) soluble P (0.12,0.12 and 0.14%) than that (0.16%) of birds fed diet 1 (no phytase). Litter from birds fed diet 5 had greater ($P < 0.05$) soluble P than litter from birds fed diets 2, 3 and 4. The proportion of total P that was constituted by soluble P was greater ($P < 0.05$) in litter from diets 3, 4 and 5 (phytase containing diets) than that in litter from diets 1, 2 and 6 (which contained no added phytase), yet the amount of soluble P was lower in phytase containing diets. In this series of experiments, adding feed additives without appropriate reduction in dietary total P resulted in increased soluble P as a percent of total P in litter. Feeding birds closer to nPP requirements resulted in a decrease in total P and soluble P and in the soluble P to total P ratio as compared to those fed NRC nPP levels (diets 2 versus 1).

Turkey Trials

Thompson et al. (2002) conducted two experiments (two flocks on same litter) to determine the feasibility of lowering phosphorus (P) levels when phytase and 25-OH vitamin D_3 (HyD) are added alone and in combination in diets for turkeys. Toms were fed one of nine diets consisting of an industry diet; an NRC diet; or a diet containing 83% of the NRC requirement for P. The Industry and NRC diets contained 0 or 600 FYT/kg phytase (P reduced 0.08%), 0 or 50 ug/kg 25-OH D3 (P reduced 0.03%), or a combination thereof. Birds fed the Industry and NRC diets (18 wk BW = 34.6 lb) were heavier from 0 to 18 weeks as compared with toms fed the Low P diet (18 wk BW = 32.9 lb). Reductions of dietary P when 600 FYT phytase/kg and/or 50 ug 25-OH D3/kg were added to the diet did not significantly affect tom performance at any point during the course of the experiment. Feeding P levels at NRC recommendations reduced litter P concentration from 1.6 to 0.83%. Addition of phytase to the industry nPP diet reduced litter P concentrations an additional 0.3%. After two flocks of turkeys reared on the same litter and on the same diet, the soluble P concentration and ratio of soluble P –to- total P was not significantly affected by diet. Notably, moisture content of litters at the end of two flocks was approximately 20 percent. As discussed below, the moisture content and microbial load in the litter may have more influence on solubility of P than dietary phytase supplementation *per se*.

These results suggest that the concentration of P fed can be substantially reduced with supplemental phytase and/or 25-OH D3 with no detrimental effects on performance. In addition, NRC concentrations of P were adequate for support of growth throughout the trial, with toms fed P concentrations below NRC performing similarly from 9 to 18 wk of age.

Phytase – where is it active in the animal and is it still active in the litter?

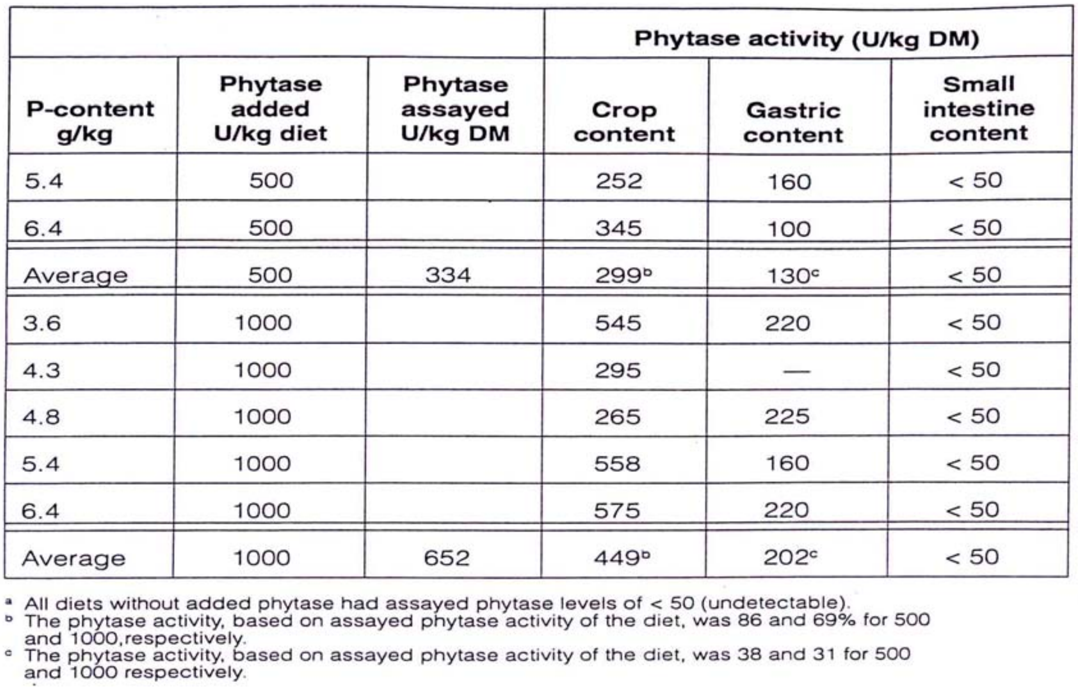
Increases in soluble P in runoff from soils where the litter applied was from broilers fed phytase as reported by DeLaune et al. (2001) also raise the question of whether phytase is still active in the lower digestive tract or in the excreta and litter. In studies with mini-pigs, Rapp et al. (2001) reported that phytase activity in the lower small intestine during the first 12 hours after feeding was negligible and similar between pigs fed diets with or without fungal phytase, both in wheat-based, or corn-SBM based diets. Similarly, Jongbloed et al. (1992) noted negligible phytase activity in the terminal ileum in pigs fed 1500 U phytase/kg diet (Table 5).

Table 5. Denaturation of phytase in the intestinal tract of pigs (Jongbloed et al., 1992)

Diet	Feed phytase activity (U/kg)	Upper small intestine phytase activity (U/kg)	Lower small intestine phytase activity (U/kg)
Corn-SBM[1]	< 50	< 50	< 50
Corn-SBM + fungal phytase[1]	1575	1330	< 50

Similar results have been noted in broilers (Leibert et al., 1993; Table 6) when they were fed diets containing 500 or 1000 U phytase/kg diet; whereby phytase activity in the small intestine was negligible (i.e. indistinguishable from diets without supplemental phytase). So, it appears that dietary phytase activity is negligible when the digesta reaches the lower small intestine. Recently, excreta from broilers fed different levels of phytase (0 to 6000 U phytase/kg diet) was analyzed after being freeze dried, for phytase activity (Angel et al., unpublished data). The results clearly demonstrate that there was no difference in the phytase activity of excreta from broilers fed a diet with no added phytase and one with 6000 U of added phytase per keg diet. Some phytase activity was seen in excreta from birds being fed all treatments, irrespective of phytase inclusion. This phytase activity averaged 70 U phytase / kg excreta. These results imply that any differences in soluble P in manure could not plausibly be attributable to dietary phytase. Rather, differences in lower-GIT microflora or differences in litter conditions and litter microorganisms may initiate the release of P and increase water-soluble P concentrations as was observed by DeLaune et al. (2001).

Table 6. Phytase activity in diets and gastrointestinal tracts of 3 to 5 week old chickens fed diets with added phosphorus and microbial phytase. (From Leibert *et al*., 1993)



			Phytase activity (U/kg DM)		
P-content g/kg	Phytase added U/kg diet	Phytase assayed U/kg DM	Crop content	Gastric content	Small intestine content
5.4	500		252	160	< 50
6.4	500		345	100	< 50
Average	500	334	299[b]	130[c]	< 50
3.6	1000		545	220	< 50
4.3	1000		295	—	< 50
4.8	1000		265	225	< 50
5.4	1000		558	160	< 50
6.4	1000		575	220	< 50
Average	1000	652	449[b]	202[c]	< 50

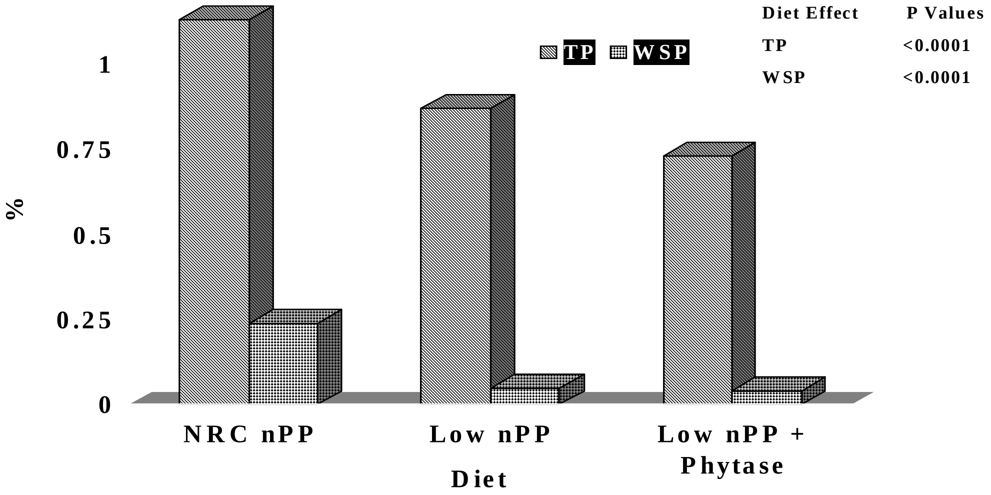
[a] All diets without added phytase had assayed phytase levels of < 50 (undetectable).

[b] The phytase activity, based on assayed phytase activity of the diet, was 86 and 69% for 500 and 1000,respectively.

[c] The phytase activity, based on assayed phytase activity of the diet, was 38 and 31 for 500 and 1000 respectively.

Further, Newman et al. (2002) conducted a trial to validate that fungal phytase supplementation is inactive and does not contribute to an increase in proportion of soluble P in excreta. Within the experiment, 20 day-old broilers were fed diets with or without fungal phytase. Excreta was collected immediately following excretion and placed in a container on an ice bath. Pen excreta were mixed well and subdivided into three equal aliquots. One aliquot was frozen immediately, a second aliquot was incubated for 48 hr with an antifungal and antibiotic and the remaining aliquot incubated for 48 hr at 37 C under aerobic conditions. After excreta treatment, all samples were frozen, freeze-dried and analyzed for total and soluble P.

Figure 1. Effect of Diet on Total and Water Soluble P in Broiler Excreta, At Time of Excretion (Newman et al., 2002)



This experimental protocol allowed for the determination of: 1) the effect of phytase when it was added to diets where the dietary P concentration had been lowered to account for how much P would be liberated by phytase on excreta total and water soluble P at the time excreta is voided, and 2) the effect of holding excreta for 24 or 48 hours at 37 C under aerobic conditions in diets with or without phytase thus determined what mediates the change in water soluble P that occur after excreta has been voided. Excreta total P at excretion time was lower in birds fed the low P diet and was further decreased when phytase was added to the low nPP diet (Figure 1). Water soluble P was lower in the low nPP diets and no difference was seen between the low nPP diet with or without phytase (Figure 1). The addition of fungal phytase to chick diets resulted in decreased total and water soluble P in excreta when the dietary P was reduced to reflect the level of P that phytase made available. Holding (incubating) excreta for 24 or 48 hr after it was voided resulted in increases in water soluble P regardless of diet (Figure 2). Thus, correct inclusion of phytase in broiler diets decreases both total and soluble P.

The ratio of water soluble to total P (Figure 3) was dramatically decreased in the low nPP and the as excreted (0 time) excreta from broilers fed the low nPP and the low nPP plus phytase diet. There was no effect on this ratio of when phytase was added to a low nPP diet. Incubating the excreta after it was voided resulted in an increase in water soluble to total P ratio but the ratio after incubation was similar regardless of dietary treatment. These results suggest that: 1) Phytase does not increase water soluble P content in excreta when the diet is formulated to a lower P concentration that accounts for the P made available by phytase, 2) the increase in P solubility that occurs after excreta is voided by the bird is primarily due to microbial activity in the excreta after excretion and *not* due to dietary fungal phytase supplementation.

Figure 2. Effect of Diet on Water Soluble P in Broiler Excreta – As Excreted or Incubated for 24 or 48 h at 37 C (Newman et al., 2002)

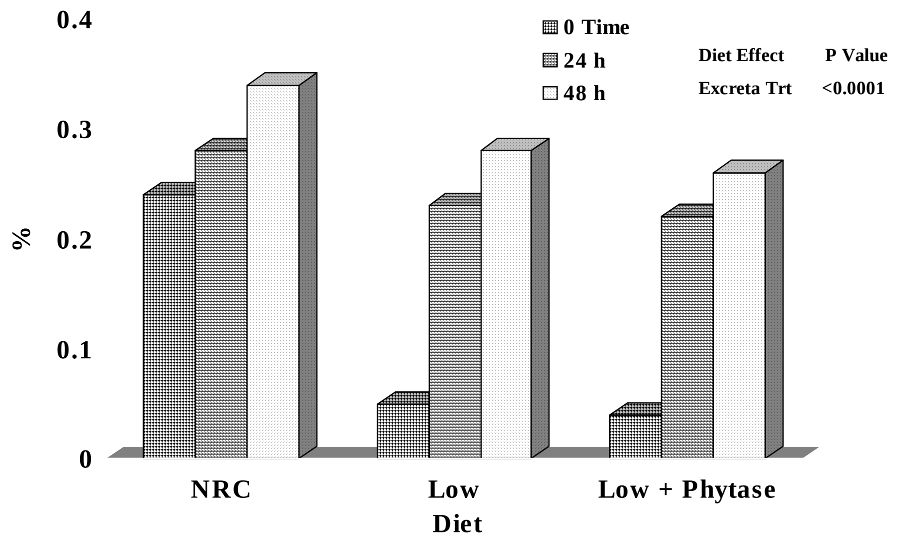
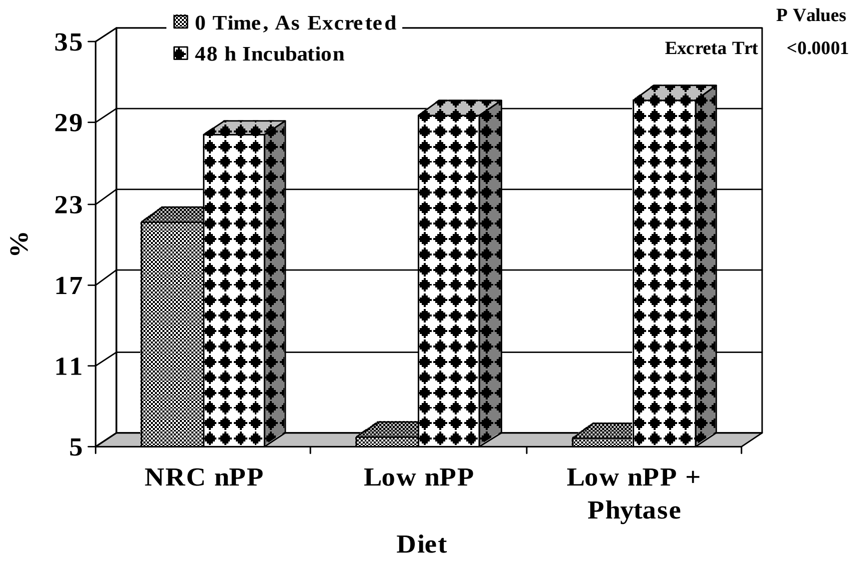
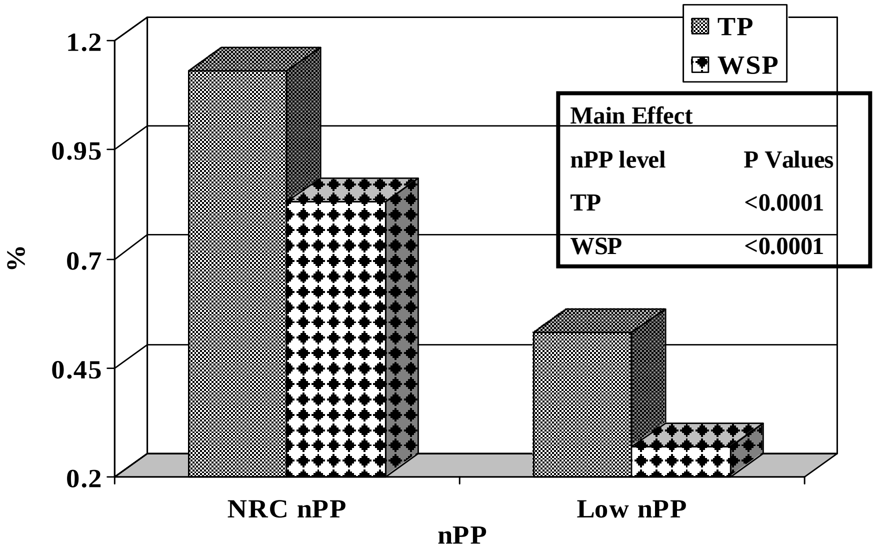


Figure 3. Effect of Excreta Treatment on Water Soluble to Total P Ratio in Broilers – As Excreted and After 48 H (Newman et al., 2002)



Based on the results of this study an additional four trials were done with broilers, turkeys and pigs to confirm the results of the first study and to determine what is causing the increase in water soluble P in excreta after it is voided. The experimental design was similar to that of the first experiment, but in these experiments excreta was incubated (held) at 37 C, under anaerobic conditions for 72 hr, in the presence or absence of antimicrobial and antifungal agents. As in the above experiment (Newman et al., 2001) reducing dietary nPP concentration in broiler diets reduced total and water soluble P (Figure 4). Additionally, phytase was added to a diet that had not had its nPP reduced. This treatment resulted in no change in total P in the excreta but an increase in water soluble P content from 0.31 to 0.39% in the NRC nPP and NRC nPP plus phytase diet. Dietary phytase, however, had no effect (P >0.05) on the concentration of soluble P or the ratio of soluble P to total P of excreta, either before or after incubation. During incubation, water soluble P increased from 0.21 to 0.77% (water soluble concentration on a dry matter basis) when no antibiotics were used and when antibiotics were use the water soluble P concentration was similar (0.23%) to the as excreted concentration level. This supports previous findings (Leibert *et al.*, 1993) where exogenous phytase in the digesta was not detectable after the gastric area and thus should not be present in the excreta. There was no difference in the level of soluble P in excreta from birds fed a low P diet with or without phytase. The primary modifier of water soluble to total P ratio was incubation in the absence of antimicrobials (Figure 6). Similar results were seen in the turkey (Figure 7) and pig trials.

Figure 4. Main Effect of Diet nPP on Total and Water Soluble P in Broiler Excreta (Angel et al., unpublished)



Overall, the results of these experiments support the following: 1) Incorrect use of phytase results in no changes in total P and an increase in water soluble P in excreta; 2) Phytase, when used correctly will lower both excreta total and water soluble P; 3) Microbial activity in the excreta after it is voided accounts for most of the changes that are seen in water soluble P levels in excreta and these occur similarly in the presence or absence of phytase.

Figure 5. Main Effect of Phytase on Total and Water Soluble P in Broiler Excreta (Angel et al., unpublished)

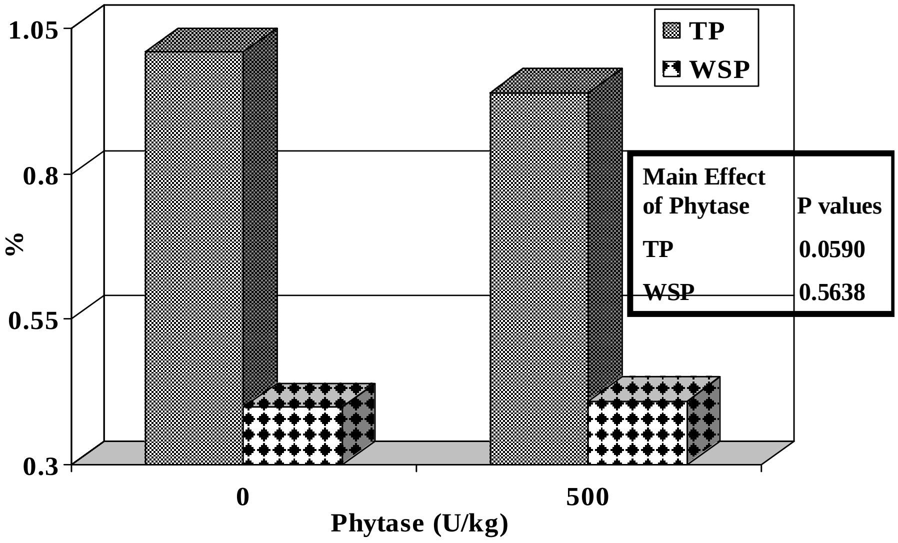


Figure 6. Effect of Non-Phytin Phosphorus (nPP) Level and Phytase on Water Soluble to Total P Ratio in Broiler Excreta (Angel et al., unpublished)

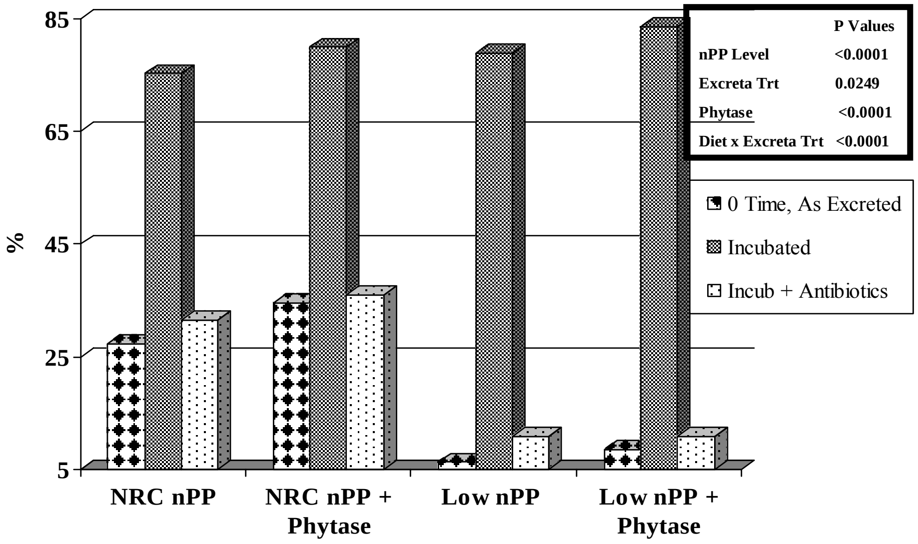
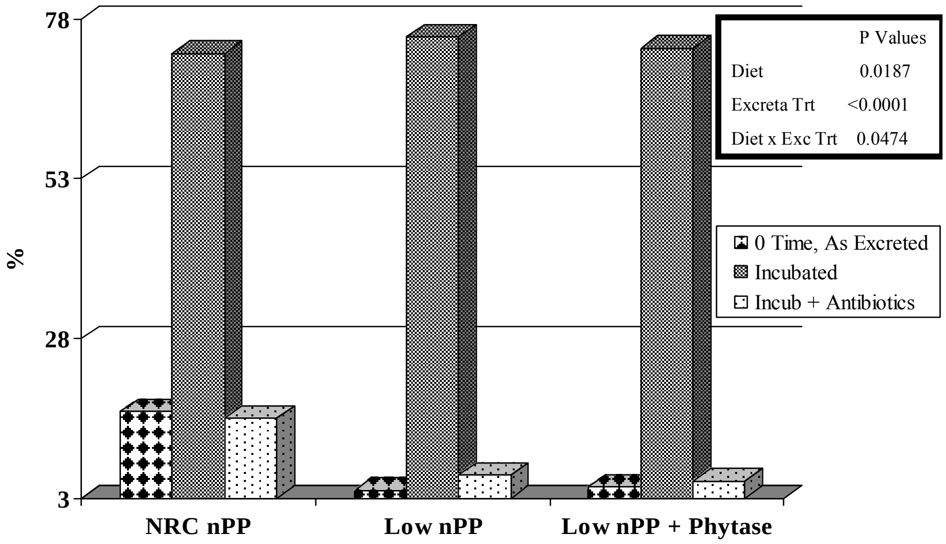


Figure 7. Effect of Diet on Water Soluble to Total P Ratio in Turkey Excreta (Angel et al., unpublished)



Conclusions

As the new EPA confined animal feeding operation rules are enacted over the next few years and producers shift to a P-based manure application, the need for fully understanding the impact of diet on the proportion of soluble P in manure and litter is critical. Given recent studies in our laboratories, it does not appear that fungal phytase supplementation influences the proportion of soluble P in litter of broilers or turkeys, which is contrary to the report of DeLaune et al. (2001). Additionally, the scientific literature refutes the presumption that phytase from the diet remains active upon excretion by the animal. Further, upon incubation the increase in proportion of soluble P occurs primarily from microbial activity in the manure itself. If this is true, factors influencing litter and excreta moisture (such as sodium content or acid-base balance) may have more of an influence on increasing the proportion of soluble P. Further research on digestibility of inorganic P sources and rapid analyses of P composition in feedstuffs will substantially allow for further reductions in safety margins for P and substantially reduce excretion of excess P.

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