Reducing Phosphorus in Animal Manures

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1. **Additive effects of 1,25-dihydroxycholecalciferol and phytase on phytate phosphorus utilization and related parameters in broiler chickens.**
   NAL Call Number: DNAL 47.8-Am33P
   Abstract: Two experiments were conducted to compare the effects of supplementation with 1,25-dihydroxycholecalciferol [1,25-(OH)2D3] and a commercial phytase on P utilization by broiler males. Experiment 1 was conducted with three levels of total dietary P (0.45, 0.55, and 0.65%) in
corn-soybean meal diets supplemented with 5 microgram/kg of 1,25-(OH)2D3, 600 units/kg of phytase, or the combination of these supplements in a factorial arrangement from 0 to 21 d in battery brooders. A second experiment was conducted with a similar design except that it was carried out in floor pens for a period of 35 d. In Experiment 1, maximal BW was obtained at 0.65% P in chicks receiving the basal diet, 0.55% P in chicks receiving phytase or 1,25-(OH)2D3, and 0.45% P in chicks fed both supplements. Bone ash for chicks receiving the basal, phytase, 1,25-(OH)2D3, and combination treatments at 0.45% total dietary P were 26.6, 34.9, 35.1, and 38.8%. There were significant interactions between phytase and 1,25(OH)2D3 for BW, bone ash, and incidence of rickets. Similar results were noticed in Experiment 2, with the exception that 1,25-(OH)2D3 had little influence on BW from 0 to 3 wk, likely due to slightly higher dietary P. From 3 to 5 wk, BW and bone ash were increased by each supplement and further increased by their combination. These interactions suggest different mechanisms of action for these supplements in influencing phytate P utilization.

2. **Best management practices for phosphorus management to protect surface water.**
Mahler,-R.L.; Bailey,-B.G.; Mahler,-K.A.
NAL Call Number: DNAL 275.29-Id131dc

3. **Components of dairy manure management systems.**
Van-Horn,-H.H.; Wilkie,-A.C.; Powers,-W.J.; Nordstedt,-R.A.
NAL Call Number: DNAL 44.8-J822
Abstract: Dairy manure management systems should account for the fate of excreted nutrients that may be of environmental concern. Currently, regulatory oversight is directed primarily at the assurance of water quality; N is the most monitored element. Land application of manure at acceptable fertilizer levels to crops produced on the farm by hauling or by pumping flushed manure effluent through irrigation systems is the basis of most systems. Nutrient losses to surface and groundwaters can be avoided, and significant economic value can be obtained from manure as fertilizer if adequate crop production is possible. Dairies with insufficient crop production potential need affordable systems to concentrate manure nutrients, thereby reducing hauling costs and possibly producing a salable product. Precipitation of additional nutrients from flushed manures with sedimented solids may be possible. Composting of separated manure solids offers a possible method to stabilize solids for distribution, but, most often, solids separated from dairy manures are fibrous and low in fertility.
4. Decreasing phosphorus solubility in poultry litter with aluminum, calcium, and iron amendments.
Moore,-P.A.-Jr.; Miller,-D.M.
NAL Call Number: DNAL QH540.J6
Abstract: Arkansas produces approximately one billion broilers (Gallus gallus domesticus) each year. Phosphorous runoff from fields receiving poultry litter is believed to be one of the primary factors affecting water quality in northwest Arkansas. Poultry litter contains approximately 20 g P kg (-1), of which approximately 2 g P kg(-1) is water soluble. The objective of this study was to determine if soluble P levels could be reduced in poultry litter with Al, Ca, and/or Fe amendments. Poultry litter was amended with alum, sodium aluminate, quick lime, slaked lime, calcitic limestone, dolomitic limestone, gypsum, ferrous chloride, ferric chloride, ferrous sulfate, and ferric sulfate, and incubated in the dark at 25 degrees C for 1 wk. The Ca treatments were tested with and without CaF(2) additions in an attempt to precipitate fluorapatite. At the end of the incubation period, the litter was extracted with deionized water and water soluble P determined. Water soluble P levels in the poultry litter were reduced from >2,000 mg P kg(-1) litter to

5. Dietary 1,25-dihydroxycholecalciferol supplementation increases natural phytate phosphorus utilization in chickens.
Edwards,-H.M.-Jr.
Abstract: These studies were conducted to determine if supplementation of a corn-soybean meal diet with 1,25-dihydroxycholecalciferol [1,25-(OH)2D3] would increase the utilization of natural phytate phosphorus by broiler chickens. The criteria measured in these studies were weight gain, gain:feed ratio, bone ash, rickets due to phosphorus deficiency, plasma calcium and phosphorus. The highest retention of phytate phosphorus (79.4%) was obtained when both phytase and 1,25-(OH)2D3 were present in the diet. The possible mode of action and importance of these results in many areas of nutrition and environmental science are discussed.

7. Effect of chemical amendments on ammonia volatilization from poultry litter.
Moore,-P.A.-Jr.; Daniel,-T.C.; Edwards,-D.R.; Miller,-D.M.
NAL Call Number: DNAL QH540.J6
Descriptors: poultry-manure. chemical-treatment. calcium-hydroxide. inorganic-compounds.
ferrous-sulfate. ph. electrical-conductivity. carbon. metals. nitrogen. phosphorus. ammonia.
volutilization. alum. soluble-organic-carbon.
Abstract: Ammonia (NH3) volatilization from poultry litter results in a buildup of atmospheric
NH3 in chicken houses, which is detrimental to both farm laborers and birds. Ammonia loss
from litter is detrimental to the external environment because it results in acid rain, as well as
low N/P ratios in litter, which increase the likelihood of excessive P runoff into adjacent water
bodies. The objectives of this study were to determine the effect of various chemical
amendments on NH3 volatilization and selected litter characteristics after 42 d. A laboratory
study was conducted using the following amendments: Ca(OH)2 (calcium hydroxide),
Al2(SO4)3.18H20 (alum), alum + CaCO3, FeSO4.7H2O (ferrous sulfate), and MLT (Multi-
purpose Litter Treatment, a commercial product). The results of this study indicated that the
addition of alum to poultry litter dramatically reduces NH3 volatilization (up to 99% less
volatilization than controls). decreases in volatilization resulted in higher total and soluble N in
litter, which increased N/P ratios. Several of the compounds studied (particularly alum) were
effective in decreasing water-soluble P levels in litter. Therefore, we are proposing the use of
alum as a litter amendment in poultry houses.

8. Effect of diet on feces composition and the implications on environmental quality.
Sloan,-D.R.; Harms,-R.H.; Barnard,-D.; Nordstedt,-R.
NAL Call Number: DNAL SF481.J68
Descriptors: hens. experimental-diets. dietary-protein. methionine. calcium. phosphorus. feces-

9. The effect of dietary phytasae on growth performance and phosphrus utilization of
broiler chicks.
Perney,-K.M.; Cantor,-A.H.; Straw,-M.L.; Herkelman,-K.L.
NAL Call Number: DNAL 47.8-Am33P
Descriptors: broilers. chicks. diet. phytase. phosphorus. feed-intake. liveweight-gain. feed-
conversion. blood-plasma. bone-ash. breaking-strength.
Abstract: Two experiments were conducted to evaluate the effect of dietary phytase and
increasing levels of available phosphorus [P(av)] on the growth performance and phosphorus metabolism of broiler chicks. In both experiments, graded levels of P provided by dicalcium phosphate and of phytase were added to a low-P corn-soybean meal basal diet. In Experiment 1, diets providing 21, 29, 37, and 44% P(av) without phytase; 21% P(av) plus 0.5, 1.0, or 3.0% phytase; and 29% P(av) plus 1.0% phytase were each fed to four groups of seven chicks, 3 days of age. In Experiment 2, diets providing P(av) levels of 32, 38, and 44% and phytase levels of 0.9, 1.0, and 1.5% (250, 500, and 730 units/kg) in a factorial arrangement were each fed to four groups of eight chicks, 5 days of age. In Experiment 1, increasing dietary P(av), but not phytase, increased feed intake, weight gain, feed conversion, plasma inorganic P, tibia and toe ash and tibia breaking strength (P less than or equal to .05). Plasma inorganic P responded quadratically to increasing dietary phytase. In Experiment 2, feed intake and weight gain were increased by elevating the level of P(av), but not by phytase. Toe and tibia ash and plasma inorganic P were increased by dietary phytase and increasing levels of P(av) (P less than or equal to .01). Tibia breaking strength was improved (P less than or equal to .05) by dietary phytase but not by increasing levels of P(av). The P excretion was elevated (P less than or equal to .01) by increasing levels of P(av) and was decreased by supplemental phytase (P less than or equal to .05). Dietary phytase added to diets low in P(av) was able to improve some, but not all variables studied.

10. Effect of microbial phytase on nitrogen and amino acid digestibility and nitrogen retention of turkey poult fed corn-soybean meal diets.
Yi,-Z.; Kornegay,-E.T.; Denbow,-D.M.
NAL Call Number: DNAL 47.8-Am33P
Descriptors: poult. feed-additives. phytase. nitrogen-retention. digestibility. amino-acids. maize. soybean-oilmeal. dietary-protein. phosphorus. digits. bone-ash. liveweight gain. feed-conversion. feed-intake. dietary-minerals. calcium. crude-protein. apparent digestibility. ideal-digestibility. Abstract: The effect of microbial phytase on N and amino acid (AA) digestibility and N retention was investigated in a 29-d trial using 480 Nicholas Large White Turkey female poult fed corn-soybean meal diets. A 2 X 2 X 2 factorial arrangement of treatments was used with 0.45 and 0.60% nonphytate P (nP), 22.5 and 28.0% CP, and 0 and 750 U of microbial phytase/kg of diet. At 0.45% nP, adding phytase to either 22.5 or 28.0% CP diets increased BW gain (P < 0.01), and percentage (P < 0.01) and weight (P < 0.10) of toe ash; at 0.60% nP, the magnitude of the effect of phytase was less (P > 0.10) than observed for 0.45% nP and inconsistent. Microbial phytase enhanced growth performance, toe ash, ideal N and AA digestibility, and apparent N and P retention.

11. The effect of supplementary Aspergillus niger phytase in diets for pigs on concentration and apparent digestibility of dry matter, total phosphorus, and phytic acid in different sections of the alimentary tract.
Jongbloed,-A.W.; Mroz,-Z.; Kemme,-P.A.
Abstract: Six barrows of approximately 37 kg BW, fitted with two simple T-cannulas in the duodenum (25 cm posterior to the pylorus) and terminal ileum (12 to 15 cm anterior to the ileocecal junction), were fed two diets containing 2.1 g of P/kg in the form of phytic acid and a low intrinsic phytase activity (corn-soybean meal based diet [Diet A] or a typical Dutch diet [Diet B]) without or with supplementary microbial phytase from Aspergillus niger (var. ficuum) equal to 1,500 phytase units per kilogram of diet, in a crossover design. The apparent duodenal, ileal, and total tract (overall) digestibilities of DM, total P, and phytate P (phytic acid X .282) were calculated using both Cr-NDR (neutral detergent residue mordanted with Cr) and Co-EDTA as dual-phase markers. Concentration of total P in the ileal digesta (P < .01) and feces (P < .01) of pigs fed microbial phytase was lower than without this enzyme, irrespective of the diet. Ideal digestibility of total P was 18.5 and 29.8 percentage units higher (which was a 1.7- to 2.9-fold increase) due to added Aspergillus niger phytase (P < .05). Also, total tract (overall) digestibility increased by 27.0 to 29.7 percentage units (P < .01). Phytic acid concentration in the duodenal and ileal digesta of pigs receiving microbial phytase was lower (P < .01 or.001), resulting in its higher ileal digestibility (dephosphorylation rate) by 50.1 percentage units for Diet A and by 75.4 percentage units for Diet B. Irrespective of the treatment, no phytase activity could be detected in the ileal digesta of pigs.

12. The effect of varying bone meal sources on phosphorus utilization by 3-week old broilers.
Orban,-J.I.; Roland,-D.A.-Sr.
Descriptors: broilers. bone-meal. particle-size. phosphorus. nutrient-requirements.

13. Effects of phytase and 1,25-dihydroxycholecalciferol on phytate utilization and the quantitative requirement for calcium and phosphorus in young broiler chickens.
Poultry-sci. Savoy, IL : Poultry Science Association, Inc. Jan 1996. v. 75 (1) p. 95-110. NAL Call Number: DNAL 47.8-Am33P
Abstract: Three experiments were conducted to determine the effects of supplementing 1,25-dihydroxycholecalciferol [1,25-(OH)2D3] and a commercial phytase product on Ca and P requirements of to 21-d-old broiler males. These experiments were conducted with four levels of dietary Ca and P in corn-soybean diets with and without supplementation of 5 microgram/kg of 1,25-(OH)2D3, 600 units/kg of phytase, and the combination of these supplements. The results
show that these levels of phytase and 1,25-(OH)2D3 can replace up to 0.1% of the inorganic P for criteria such as BW, bone ash, and plasma P. Both supplements increased phytate P retention, whereas higher levels of Ca and P decreased phytate P retention. The addition of 1,25-(OH)2D3, but not phytase, reduced Ca requirements and decreased the incidence of tibial dyschondroplasia. The combination of these levels of phytase and 1,25-(OH)2D3 replaced 0.2% inorganic P for criteria such as BW, bone ash, and P rickets. Total dietary P requirements are estimated to be between 0.55 and 0.60% at the levels of phytase and 1,25-(OH)2D3, listed above, or 0.45% when the combination is added. The Ca requirements are estimated to be 0.77% when 1,25-(OH)2D3 is added to the diet and 0.9 to 0.95% when phytase is added.

14. The efficacy of an enzymic cocktail and a fungal mycelium in dephosphorylating corn-soybean meal-based feeds fed to growing turkeys.
Zyla,-K.; Ledoux,-D.R.; Kujawski,-M.; Veum,-T.L.
Poultry-sci. Savoy, IL : Poultry Science Association, Inc. Mar 1996. v. 75 (3) p. 381-387. NAL Call Number: DNAL 47.8-Am33P
Abstract: A study was conducted to determine the efficacy of phytase, an enzymic cocktail, and a waste Aspergillus niger mycelium to hydrolyze phytate present in corn-soybean meal diets. One hundred turkey poults were assigned to dietary treatments for 2 wk (Days 7 to 21). Dietary treatments included: 1) NRC (1994) diet (NRC), with recommended concentration of 0.6% available P (aP) and 1.2% Ca; 2) Phytase diet (PHYT), 3) cocktail diet (COC), 1,000 units of phytase/kg diet plus acid phosphatase (100 units/g of diet), acid protease (42 units/g of diet), pectinase (2.94%), 0.16% aP, and 0.84% Ca; 4) Fungal mycelium diet (MYC), 5% mycelium, 0.16% aP, and 0.84% Ca; and 5) a positive control diet (CTRL+), 0.42% aP, and 0.84% Ca. Turkeys fed the PHYT diet consumed less feed and gained less weight but retained more P than poults fed the CTRL+ or NRC diets. Poult fed the COC diet performed as well as poult fed CTRL+ or NRC diets but retained more P (77%) and Ca (68%). Poult fed the MYC diet retained 79% P, gained the most weight, and were more efficient than poult fed any other dietary treatment. In vitro P release from experimental diets correlated well (R = 0.906) with P retention as observed in the feeding trial. Compared with the diet containing phytase as the sole supplemental enzyme, both the enzymic cocktail and fungal mycelium enhanced performance, bone mineralization, and retention of P and Ca in growing turkeys.

15. Efficacy of supplemental microbial phytase at different dietary calcium levels on growth performance and mineral utilization of broiler chickens.
Sebastian,-S.; Touchburn,-S.P.; Chavez,-E.R.; Lague,-P.C.
Poultry-sci. Savoy, IL : Poultry Science Association, Inc. dec 1996. v. 75 (12) p. 1516-1523. NAL Call Number: DNAL 47.8-Am33P
Abstract: A 3-wk feeding trial with 240 sexed, day-old broiler chickens was conducted to determine the efficacy of microbial phytase at different levels of dietary Ca on performance and utilization of minerals in broiler chickens fed a low-P corn-soybean diet. The results show that microbial phytase supplementation to a low P diet improved growth performance and mineral utilization in broiler chickens. Dietary Ca levels had a significant effect on the response to phytase; the optimum growth performance and mineral utilization were achieved at the low (0.6%) level of dietary Ca supplemented with phytase.

Honeyman,-M.S.
NAL Call Number: DNAL S605.5.A43
Abstract: The nutrient composition of swine excreta can be altered by manipulating the composition of the pig's diet. Several approaches are reviewed--feeding according to the pig's growth phase, formulation according to the feed's digestible amino acids, use of crystalline amino acids, the ideal protein approach, formulation according to available phosphorus, and the addition of phytase enzymes. Each has the potential to lower nitrogen or phosphorus excretion levels. Together they can dramatically reduce the nitrogen and phosphorus concentration of swine manure, which could be a major advantage in regions with a high density of swine or for swine operations with limited access to arable land. However, the value of the swine manure would be much less as a fertilizer because these two elements are important plant nutrients.

17. Environmental nutrition: nutrient management strategies to reduce nutrient excretion of swine.
Kornegay,-E.T.; Harper,-A.F.
URL: Note: Online version: URL: http://www.arpas.uiuc.edu/pas/pas.html
NAL Call Number: DNAL SF51.P76

18. Enzyme applications for monogastric feeds: a review.
Campbell,-G.L.; Bedford,-M.R.
19. Evaluation of chemical amendments to reduce ammonia volatilization from poultry litter.  
Moore,-P.A.-Jr.; Daniel,-T.C.; Edwards,-D.R.; Miller,-D.M.  
Poultry-sci. Savoy, IL : Poultry Science Association, Inc. Mar 1996. v. 75 (3) p. 315-320. NAL Call Number: DNAL 47.8-Am33P  
Abstract: Ammonia volatilization from poultry litter often causes high levels of atmospheric ammonia in poultry houses, which is detrimental to both farm workers and birds. Ammonia emissions from houses also aggravate environmental problems, such as acid rain, and result in a loss of fertilizer nitrogen. The objectives of this study were to determine the effect of litter amendments on ammonia volatilization and to determine the effect of these amendments on nitrogen and phosphorus content in litter. The results of this research indicate that alum, ferrous sulfate, and phosphoric acid dramatically reduce ammonia volatilization from litter. The amount of ammonia lost from litter treated sodium bisulfate and a proprietary product made of Ca-Fe silicate with a phosphoric acid coating was not different from the control (untreated litter). Aluminum sulfate (alum) and ferrous sulfate reduced water soluble P concentrations in litter, whereas phosphoric acid greatly increased water-soluble P levels. The most effective compound evaluated with respect to reducing both ammonia loss and P solubility was alum.

20. Improvement of phytate phosphorus utilization by a microbial phytase in weanling pigs.  
Lei,-X.G.; Ku,-P.K.; Miller,-E.R.; Yokoyama,-M.T.  
Descriptors: piglets. microbial-activities. phytase. phytates. phosphorus. utilization.  

21. Improving phytate phosphorus availability in corn and soybean meal for broilers using microbial phytase and calculation of phosphorus equivalency values for phytase.  
Yi,-Z.; Kornegay,-E.T.; Ravindran,-V.; Denbow,-D.M.  
Poultry-sci. Savoy, IL : Poultry Science Association, Inc. Feb 1996. v. 75 (2) p. 240-249. NAL Call Number: DNAL 47.8-Am33P  
Abstract: Two experiments were conducted to determine the effectiveness of Natuphos phytase
for improving P availability of soybean meal-based semi-purified diets (SP, Experiments 1 and 2) and corn-soybean meal-based diets (CS, Experiment 2) fed to broilers (1 to 21 d). There were 360 and 288 birds fed the SP diets in Experiments 1 and 2, respectively, and 288 birds were fed the CS diets in Experiment 2. Phosphorus equivalency values for phytase were calculated. The basal diets were formulated to contain 0.27% nonphytate P (nP); the SP basal diet contained 0.45% total P (tP) that included 0.17% P as defluorinated phosphate; the CS basal diet contained 0.51% tP that contained 0.12% P as defluorinated phosphate. Both basal diets were supplemented with defluorinated phosphate to provide 0.36, 0.45, or 0.54% nP or with 350, 700, or 1,050 U of phytase/kg diets. Supplementing defluorinated phosphate and phytase linearly increased BW gain (P < 0.001), feed intake (P < 0.001), and percentage ash of dried toes (P < 0.01). Phytase addition increased apparent retention of P (P < 0.02), Ca (P < 0.005 in Experiment 2), and N (P < 0.06 in Experiment 2 for CS), increased apparent digestibility of DM (P < 0.04), and linearly decreased (P < 0.005) P excretion. In comparison to the 0.45% nP diet, P excretion was reduced 42 to 51% by addition of phytase. The addition of defluorinated phosphate linearly decreased apparent retention of P (P < 0.02) and Ca (P < 0.005 in Experiment 2), and increased P excretion (P < 0.007). The average of released P by phytase calculated by solving nonlinear or linear response equations of P and phytase levels for SP diets in Experiments 1 and 2 gave a P equivalency value of 1 g P = 1,146 U of phytase. The P equivalency value for CS diets fed only in Experiment 2 was 785 U of phytase = 1 g P as defluorinated phosphate. These studies show that microbial phytase is effective for improving P availability and for decreasing P excretion. Added phytase can also increase Ca and N retention.

NAL Call Number: DNAL QH540.J6
Abstract: The accelerated eutrophication of most freshwaters is limited by P inputs. Nonpoint sources of P in agricultural runoff now contribute a greater portion of freshwater inputs, due to easier identification and recent control of point sources. Although P management is an integral part of profitable agrisystems, continued inputs of fertilizer and manure P in excess of crop requirements have led to a build-up of soil P levels, which are of environmental rather than agronomic concern, particularly in areas of intensive crop and livestock production. Thus, the main issues facing the establishment of economically and environmentally sound P management systems are the identification of soil P levels that are of environmental concern; targeting specific controls for different water quality objectives within watersheds; and balancing economic with environmental values. In developing effective options, we have brought together agricultural and limnological expertise to prioritize watershed management practices and remedial strategies to mitigate nonpoint-source impacts of agricultural P. Options include runoff and erosion control and P-source management, based on eutrophic rather than agronomic considerations. Landowner options to more efficiently utilize manure P include basing
application rates on soil vulnerability to P loss in runoff, manure analysis, and programs encouraging manure movement to a greater hectareage. Targeting source areas may be achieved by use of indices to rank soil vulnerability to P loss in runoff and lake sensitivity to P inputs.

23. **Microbial phytase improves amino acid utilization in young chicks fed diets based on soybean meal but not diets based on peanut meal.**
Biehl,-R.R.; Baker,-D.H.
NAL Call Number: DNAL 47.8-Am33P

24. **New corn varieties to provide feed options in the future.**
Stilborn,-H.L.; Crum,-R.C.-Jr.
NAL Call Number: DNAL 286.81-F322

25. **Nutrient content of dairy manure from three handling systems.**
Rieck-Hinz,-A.M.; Miller,-G.A.; Schafer,-J.W.
NAL Call Number: DNAL S539.5.J68
*Abstract*: Animal manure is often used as a source of crop nutrients. Unfortunately the nutrient content of manure is quite variable. The objectives of this study were to: (i) evaluate the nutrient content of dairy manure from different handling systems and determine if published nutrient credits are outdated, (ii) determine if the nutrient content could be estimated from the solid content of the manure, and (iii) determine the seasonal variation of the nutrient content of manure. Three dairy-manure handling systems, dairy feedlots, dairy barn cleaners, and dairy bedded packs, were sampled sequentially from June 1990 to April 1992. Manure was sampled by handling system at 13 farms located in northeastern Iowa Samples were analyzed for total Kjeldahl N (TKN), ammonium-N, P2O5, K2O, and solid content. The nutrient values found in this study were higher than values previously reported in Iowa and other midwest states. For dairy feedlot manure, solid content of the manure was correlated with the nutrient content of the
manure. The use of manure in a nutrient management program is dependent on accurate nutrient recommendations based on thorough and timely manure sampling.

26. **Nutrient emissions from agriculture in the Netherlands causes and remedies.**
Boers,-P.C.M.
NAL Call Number: DNAL TD420.A1P7-v.33-no.4/5

27. **Nutrition and crop selection may have big impact on reducing nutrient losses.**
Kohn,-R.A.
NAL Call Number: DNAL 286.81-F322

28. **Phosphorus equivalence of microbial phytase in turkey diets as influenced by calcium to phosphorus ratios and phosphorus levels.**
Qian,-H.; Kornegay,-E.T.; denbow,-D.M.
NAL Call Number: DNAL 47.8-Am33P
Abstract: Male day-old turkey poults (n = 768) were fed 0, 300, 600, or 900 U of phytase/kg of a corn-soybean diet in combination with four Ca:total P (tP)ratios of 1.1, 1.4, 1.7, and 2.0:1, and two levels of nonphytate P (nP) of 0.27 and 0.36% in a 21-d trial. Dietary Ca:tP ratios were obtained by varying defluorinated phosphate and limestone at the expense of cornstarch. The detrimental effect (P < 0.02) of widening the Ca:tP ratio was observed for all measurements at each phytase and P level, and was greatest at lower phytase and P levels. Widening the Ca:tP ratio from 1.4 to 2.0 decreased the phytase efficacy by 7.4 and 4.9%, respectively, for 0.27 and 0.36% nP diets, which was close to the decrease in the phytase activity in vitro by 7.5 and 6.7%, respectively. The largest responses to supplemental phytase were achieved when poults were fed
diets with 600 and 900 U of phytase/kg diet, respectively, for 0.36 and 0.27% nP, and for Ca:tP ratios ranging from 1.1 to 1.4:1. Based on an assessment for the R2 and P values of equations, BW gain, feed intake, toe ash content, and P retention were sensitive measurements of the response to phytase addition. Equivalent equations were developed to determine the P equivalency of supplemental phytase. About 652 and 963 U of phytase were equivalent to 1 g nP, respectively, for 0.27 and 0.36% nP diets in turkey poultis from hatch to 21 d of age.

29. Phosphorus nutrition of beef cattle in northern Australia.
McCosker,-Terry.; Winks,-Lyle.
NAL Call Number: DNAL SF203.P47--1994

30. Phosphorus solubilization and its affect on the environment.
Roland,-D.A.; Gordon,-R.W.

31. Phosphorus utilization in pigs with phytase.
Sutton,-A.L.; Adeola,-O.; Schinckel,-A.P.; Kelly,-D.T.
NAL Call Number: DNAL 49.9-Eu7-no.88

32. Phytase activity, phosphorus and calcium retention, and performance of single comb White Leghorn layers fed diets containing two levels of available phosphorus and supplemented with direct-fed microbials.
Nahashon,-S.N.; Nakaue,-H.S.; Mirosh,-L.W.
NAL Call Number: DNAL 47.8-Am33P
Abstract: The presence of phytase activities in condensed cane molasses solubles (CCMS) and CCMS-Lactobacillus (Lacto) were determined. Single Comb White Leghorn layers were fed .25 and .45% available P (AP) diets supplemented with CCMS and CCMS-Lacto for nine 28-d periods to determine phytase activities of the gastrointestinal (GI) tract contents and intestine, liver, and pancreatic tissues, the GI tract pH, the P and Ca retention, and layer performance. Six dietary treatments were corn-soybean (C-S) control, C-S + CCMS, and C-S + CCMS-1, 100 mg Lacto/kg diet (ppm) [4.4 X 10(7) cfu/mg Lacto] each with .25 and .45% AP. The CCMS were used as a carrier for the Lacto, and the CCMS and CCMS-Lacto premix were incorporated at 2% of the diets. Phytase activity was much higher in CCMS-Lacto premix than in CCMS. Phytase activities of the crop contents were higher with the CCMS-Lacto diets regardless of the AP level. Intestinal phytase activity was higher with the .45% AP CCMS-Lacto diet than the unsupplemented .45% AP diets. Lactobacillus supplementation did not stimulate phytase activities in the intestinal contents or liver and pancreatic tissues. The pH of the crop and intestinal contents were much lower for the Lacto-fed layers than the layers fed unsupplemented diets regardless of dietary AP levels. No differences in Ca retentions were observed with Lacto supplementation regardless of the dietary AP levels. However, higher P retentions were observed with the Lacto supplementation in the .25% AP diet. Layers fed .25 and .45% AP Lacto-supplemented diets had lower hen-day egg production, poorer feed conversion value, consumed slightly more feed, produced less egg mass, and laid larger eggs than the layers fed .25 and .45% AP unsupplemented diets. Lacto supplementation to .25% AP diet produced eggs with higher specific gravity than the unsupplemented .45% AP diet, but not different from unsupplemented .25% AP diet. Layers fed the .25% AP diets had lower BW gains than layers fed the .45% AP diets regardless of Lacto supplementation. Phytase activity was present in the Lacto source, and the presence of phytase and Lacto supplementation to a .25% AP diet improved P retention in layers.

33. Phytase-containing transgenic seeds as a novel feed additive for improved phosphorus utilization.
NAL Call Number: DNAL QH442.B5

34. Phytate content of excreta and phytate retention in the gastrointestinal tract of young chickens.
Sooncharernying,-S.; Edwards,-H.M.-Jr.
NAL Call Number: DNAL 47.8-Am33P
Abstract: A HPLC procedure was used to determine inositol phosphate in chicken droppings and intestinal content. When compared with the classical ferric chloride method of determining total inositol phosphate in excreta, the HPLC method gave higher values, but the linear relationship between values determined by the two methods was significant (r = .82, P < .014). Holding fecal samples at room temperature (22°C) from 0 to 32 h before analysis for inositol phosphates had no effect on the concentration of inositol hexaphosphate, and, although there were significant effects on inositol pentaphosphate, the results were difficult to interpret. The results indicated very little hydrolysis of inositol phosphate in the excreta of these chickens as they lay on a dropping tray. Excreta from 3-wk-old birds contained significantly less inositol pentaphosphate than excreta from 2-wk-old birds. The excreta from birds receiving a diet containing .27% nonphytate phosphorus contained less inositol pentaphosphate than those receiving a diet containing .42% nonphytate phosphorus. The chromic oxide indicator method seemed to be feasible for determining total phytate disappearance (retention). It was not satisfactory for determining retention in various sections of the gastrointestinal tract, because there seemed to be dilution of phytate and disappearance of chromic oxide in the crop and gizzard in the chicken. There was a marked increase in the concentration of inositol hexaphosphate and to a lesser extent inositol pentaphosphate in the small intestine and cloaca as the other nutrients in the diet were digested.
38. **Reduction of phosphorus in runoff from field-applied poultry litter using chemical amendments.**
NAL Call Number: DNAL QH540.J6
*Abstract*: Field applications of poultry litter at rates to meet forage N requirements normally result in an over-application of P. Chemical amendments have the potential to reduce the solubility of manure P through precipitation and/or adsorption reactions. This study was conducted to determine the effects of two chemical amendments, alum (Al₂(SO₄)₃.14H₂O) and ferrous sulfate (FeSO₄.7H₂O), on P concentrations and load in runoff and to evaluate the effects of amended litter on forage production. Litter was broadcast applied to fescue (Festuca arundinacea Schreb.) plots at 11.2 Mg ha⁻¹ alone and in combination with alum or ferrous sulfate (1:5 amendment/litter). Rainfall simulators were used to produce three runoff events at 2, 9, and 16 d after litter application. Alum reduced the P concentrations in runoff by 87 and 63% of that from litter done for the first and second runoff events, respectively, whereas ferrous sulfate decreased runoff P concentration by 77 and 48%, respectively. Both chemical amendments resulted in significant reductions (P < 0.05) in total P load for the first runoff event. Litter application significantly increased fescue yields, with total forage yield having the greatest response to alum-amended litter. Mean forage yield with alum amended litter was 2358 kg ha⁻¹, compared with a mean yield of 1847 kg ha⁻¹ with litter alone. This was probably due to decreased NH₃ volatilization with the alum treatment. The combination of decreased P loss and increased forage yields suggest that alum-amended litter has substantial promise for use as an environmental and economic management tool in the poultry industry.

39. **Response of turkey poults to tiered levels of natuphos phytase added to soybean meal-based semi-purified diets containing three levels of nonphytate phosphorus.**
Ravindran,-V.; Kornegay,-E.T.; Denbow,-D.M.; Yi,-Z.; Hulet,-R.M.
NAL Call Number: DNAL 47.8-Am33P
*Abstract*: A 3-wk feeding trial using 920 day-old turkey poults was conducted to evaluate the addition of seven levels of phytase (Natuphos; 0, 200, 400, 600, 800, 1,000, and 1,200 U/kg of diet) to diets containing three levels of nonphytate P (nP) (.27, .36, and .45%). A positive control
diet contained .60% nP. Semi-purified basal diets contained soybean meal as the only protein source. The increase in BW gain from added phytase was greatest for the lowest nP diet (nP by phytase interaction, P < .001). At .27% nP, gains improved (P < .001) to 800 U of phytase/kg of diet and then reached a plateau. At .36 and .45% nP, increases in gains were observed only for 200 U of phytase/kg of diet. The highest phytase addition to .36 and .45% nP diets produced gains equal to those of the positive control diet. Feed intake increases paralleled those of BW gains. Gain:feed was lowest for the .27% nP diets without phytase, but improved (P < .001) to 800 U of phytase/kg of diet and then reached a plateau. The high incidence of leg disorders and high mortality (40%) observed for the poult's fed the .27% nP diet without added phytase declined with the addition of 200 to 400 U of phytase/kg of diet. Ash percentage of toes and tibias increased as the levels of nP (P < .001) and phytase (P < .01) increased; the magnitude of the response to phytase decreased as nP in the diet increased, resulting in an nP by phytase interaction (P < .001). Tibial shear force and stress responded in a similar manner to increasing levels of nP and added phytase. Results show that 652 U of microbial phytase is equivalent to 1 g of P from defluorinated phosphate in turkey starter diets using soybean meal as the only source of phytate P. The response per 100 U of phytase decreased as the total amount of phytase added was increased.

40. A review on environmental impacts of nutritional strategies in ruminants.
Tamminga,-S.
NAL Call Number: DNAL 49-J82
Abstract: Primary (plant), secondary (animal), and tertiary (human) biological systems are driven by energy, either fossil or renewable energy in biomass. Their ratio shifts from about 10:90 in primary, via 25:75 in secondary, to 90:10 in tertiary systems. Energy input in ruminant production is mainly as plants and plant parts from primary production, and the amount needed per unit product (milk, meat) primarily depends on its digestibility. This is high in young, leafy, whole plants, in roots and tubers, and in reproductive organs (whole seeds) or organ parts (by-products) of mature plants. Use of fossil energy per kilogram of DM for primary production ranges from 1 to 3 MJ in forage to over 8 MJ in concentrate feeds, whereas input per kilogram of milk is 1 to 10 MJ. Biomass energy used in ruminant production contains nitrogen (N), phosphorus (P), and potassium (K), but in a ratio rarely balanced to the animals requirements. In secondary systems, energy is partitioned between foods of animal origin and waste. The latter contains OM, N, P, K, and gases (CO2, CH4), which may cause environmental problems. Losses per kilograms of milk vary and are 10 to 45 g for N, 0 to 3 g for P, and 2 to 20 g for K. Environmental impacts of animal production can be reduced by varying the use of inorganic fertilizer and changing the forage to concentrate ratio. Digestibilities can be improved by proper harvest management. Level and ratio of dietary N, P, and K can be adjusted to requirements by selecting proper ingredients, reducing their loss in waste. Limited scope exists to reduce losses in respiration and fermentation gases.
41. Ruminant nutrition from an environmental perspective: factors affecting whole-farm nutrient balance.
Van-Horn,-H.H.; Newton,-G.L.; Kunkle,-W.E.
Abstract: Nutrient budgeting strategies focus primarily on recycling manure to land as fertilizer for crop production. Critical elements for determining environmental balance and accountability require knowledge of nutrients excreted, potential nutrient removal by plants, acceptable losses of nutrients within the manure management and crop production systems, and alternatives that permit export of nutrients off-farm, if necessary. Nutrient excretions are closely related to nutrient intake and can be predicted by subtracting predicted nutrients in food animal products exported from the farm from total nutrients consumed. Intensifying crop production with double- or triple-cropping often is necessary for high-density food animal production units to use manure without being forced to export manure or fertilizer coproducts to other farms. Most manures are P-rich relative to N largely because of 1) relatively large losses of volatilized NH3, most of it converted from urea in urine, 2) denitrification losses in soil under wet, anaerobic conditions, and 3) ability of many crops to luxury-consume much more N than P. Most soils bind P effectively and P usually is permitted to accumulate, allowing for budgets to be based on N. However, P budgeting may be required in regions where surface runoff of P contributes to algae growth and eutrophication of surface waters or where soil P increases to levels of concern. Research is needed to determine whether dietary P allowances can be lowered without detriment to animal production or health in order to lower P intake and improve N:P ratios in manure relative to fertilization needs.

42. Strategies to reduce environmental pollution from animal manure: principles and nutritional management--a review.
Paik,-I.K.; Blair,-R.; Jacob,-J.
NAL Call Number: DNAL SF55.A78A7
43. Substitution of phytase for inorganic phosphorus for turkey hens.
Ledoux,-D.R.; Zyla,-K.; Veum,-T.L.
NAL Call Number: DNAL SF481.J68

44. Supplementing corn-soybean meal diets with microbial phytase linearly improves phytate phosphorus utilization by weanling pigs.
Lei,-X.G.; Ku,-P.K.; Miller,-E.R.; Yokoyama,-M.T.
Abstract: Two experiments were conducted with weanling pigs to determine the effectiveness of a dietary supplement of Aspergillus niger phytase in improving the availability of phytate-P in corn-soybean meal diets without supplemental inorganic P. Experiment 1 consisted of two P and Ca balance trials and two feeding trials. Twelve pigs (8.18 +/- .44 kg BW) were housed individually in stainless steel metabolism cages. Six pigs received 750 phytase units (PU)/g of basal diet and the other six pigs received the basal diet without supplemental phytase as control. In Exp. 2, 96 pigs (8.81 +/- .75 kg BW) were allotted to 16 partially slotted floor pens and their basal diets were supplemented with either 0, 250, 500, or 750 PU/g for 4 wk. Individual pig weights and pen feed consumption were measured weekly. Blood samples were taken from all pigs at the end of each trial in Exp. 1 and from three pigs per pen weekly in Exp. 2 to measure serum (plasma) inorganic P (P) and Ca concentrations and alkaline phosphatase (AP) activities. The results of Exp. 1 indicated that dietary phytase increased P retention by 50% (P < .0001) and decreased fecal P excretion by 42% (P < .0001). Pigs that received dietary phytase had serum P and Ca concentrations and serum AP activities that were nearly normal, whereas control pigs had values indicative of a moderate P deficiency. Favorable effects of phytase disappeared when the phytase was removed from the diet. The results of Exp. 2 indicated a linear increase in plasma P (P < .001), ADG (P < .07), and ADFI (P < .01) with increased dietary phytase activity. Plasma AP activity decreased linearly with increased dietary phytase activity up to 500 PU/g of diet. Gain/feed and plasma Ca concentration seemed to be unaffected by dietary phytase activity. In conclusion, supplements of Aspergillus niger phytase up to 750 PU/g of feed in corn-soybean meal diets of weanling pigs resulted in a linear improvement in utilization of phytate-P.

45. Utilization of phytate phosphorus and calcium as influenced by microbial phytase, cholecalciferol, and the calcium: total phosphorus ratio in broiler diets.
Qian,-H.; Kornegay,-E.T.; Denbow,-D.M.
Abstract: The present study was performed to evaluate the potential of microbial phytase and cholecalciferol (D3) for improving the utilization of phytate P and Ca and the influence of the Ca:total (t) P ratio in a corn-soybean meal diet fed to broilers from hatch to 21 d of age. A 4 x 4 x 2 factorial arrangement of treatments was used: 1.1, 1.4, 1.7, and 2.0:1 Ca:tP ratio; 0, 300, 600, and 900 U of phytase/kg of diet; and 66 and 660 micrograms of D3/kg of diet. Another four treatments were included: the four Ca:tP ratios with 6,600 micrograms of D3 addition, but without phytase. Added phytase linearly increased (P < 0.001) BW gain, feed intake, toe ash content, and P and Ca retention. The addition of D3 in corn-soybean meal diets indicated a potential for improving the utilization of phytate P and Ca by increasing Ca and P retention by about 5 to 12% in birds, which led to an increase in toe ash content (P < 0.03). The enhanced phytate P utilization (P < 0.001) was also observed during assay of the phytase activity in the mixed diets with an addition of D3 and without added phytase. In summary, the findings of this study suggested that phytase, D3, and Ca:tP are important factors in degrading phytate and improving phytate P and Ca utilization in broilers.