Phytase and Storage: Impacts on Phosphorus Forms in Broiler Litter

Joshua M. McGrath, J. T. Sims, R. O. Maguire, W. W. Saylor, C. R. Angel, and B.L. Turner

Introduction

•Monogastric animals cannot utilize phytate phosphorus (P), the primary form of P in most grains (50-80%)

•Producers add Non-phytate P (NPP), typically as calcium phosphate, to broiler feed to provide adequate P

•The majority of the phytate P and a portion of the NPP passes through the broilers, accumulating in the litter

•In areas of concentrated broiler production the amount of P produced in manures exceeds local crop requirements

•Modification of poultry diets, using phytase in conjunction with a reduction of NPP additions, has been implemented as a means to reduce P content of broiler litter

•Concerns have been raised that dietary modification to reduce total P in broiler litter may also increase soluble P, thereby contributing to dissolved P losses in runoff

Objective

To determine the effects and interactions of broiler diet and storage on P forms and solubility in broiler litter

Materials and Methods

Pen Study

- A pen study was conducted to evaluate the impact of six diets (Table 1) on broiler health and P content in the resulting litter
- Three flocks (56 broilers per flock, 49 d per flock, 9 reps) were grown on the litter before being collected for the storage study

Storage Study

- 90 kg of BL from five pens, selected based on mortality rates, representing diets with and without phytase were collected
- The BL from each pen was stored in two 50-gallon containers at two moisture levels
  - Initial moisture content (MC, ~24%)
  - 40% MC

Broiler Litter Analysis

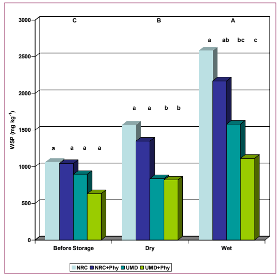
- The BL was stored in an empty broiler house for over one year and sampled monthly
- Initial samples before MC adjustment and final samples were analyzed for water soluble P (WSP: 1:10, w:v, 1 h shake, 1 h centrifuge, 0.45 µm, determined as molybdate reactive P (MRP)) and total P (microwave digestion)
- Chemically defined P fractions (by sequential fractionation) and phosphate and phytic acid concentrations (by solution ^{31}P NMR) were determined in composites of the initial and final samples
  - Sequential Chemical Fractionation: 1:200, m:v, of H_2O, 1 h shake, and 0.5 M $NaHCO_3$, 0.1 M NaOH, and 1.0 M HCl, 16 h shake, 1 h centrifuge, 0.45 µm, determined as MRP and by inductively coupled plasma-optical emission spectroscopy (ICP-OES)
  - Solution ^{31}P NMR: samples extracted in triplicate, 1:20, m:v, 0.5 *M* NaOH and 0.05 *M* EDTA, 4 h shake, 0.5 h centrifuge, diluted 50-fold analyzed for total P by ICP-OES, undiluted samples combined and lyophilized, ground to pass 500-µm sieve, immediately prior to NMR spectroscopy redissolved in 0.9 mL of 1 *M* NaOH and 0.1 mL of D_2O

Table 1. Total phosphorus concentration in the diets used to generate the litters for the storage study and the percentage of phytate phosphorus in those diets.

Diet	Starter	Grower	Finisher	Withdrawal
	Total P (%)			
NRC	0.74	0.62	0.62	0.56
NRC+Phy	0.64	0.52	0.52	0.46
UMD	0.74	0.58	0.5	0.44
UMD+Phy	0.68	0.52	0.44	0.38
	Phytate-P (% of Total P)			
NRC	39	44	43	46
NRC+Phy	45	52	52	56
UMD	39	47	54	59
UMD+Phy	43	52	61	68

Results

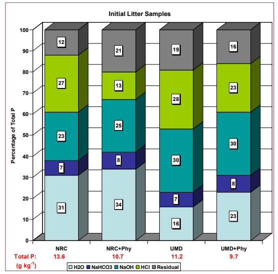
Water-soluble P in Litter Before and After Storage

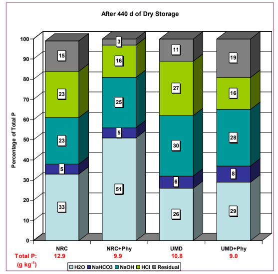


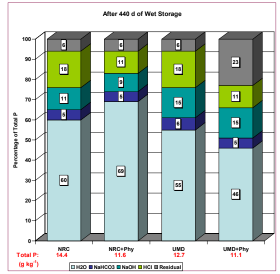
➢Initially diet did not impact litter WSP

➢Wet storage increased WSP in litter from all diets

Chemically Defined Phosphorus Forms in Broiler Litter





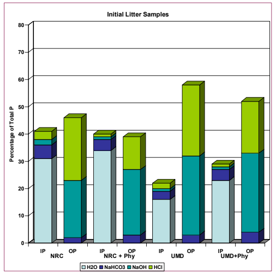


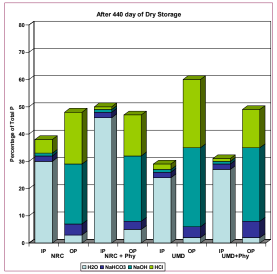
➢Reduced dietary non-phytate P in the UMD diets resulted in less H_2O and $NaHCO_3$ extractable P

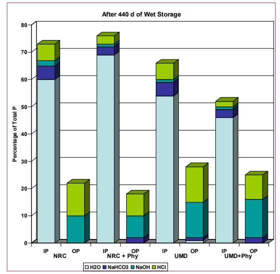
➢Phytase use shifted P from the HCl fraction to the H_2O and $NaHCO_3$ fractions

➢Wet storage dramatically increased the more readily extractable forms of P compared to dry storage

Organic and Inorganic P in Chemical Fractions





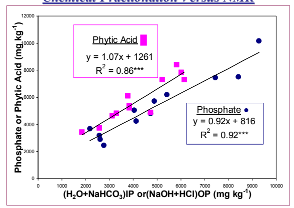


➢Phytase addition decreased NaOH and HCl extractable organic P in both the NRC and UMD diets

➢Reducing non-phytate P in the UMD diets, compared to the NRC diets, resulted in decreased H_2O and $NaHCO_3$ extractable inorganic P

➢Wet storage shifted P from the organic pool in each chemical fraction to inorganic P, but most dramatically in the H_2O and $NaHCO_3$ fractions

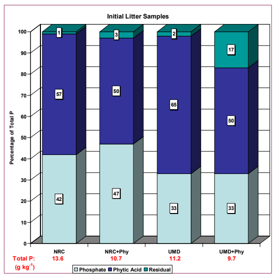
Chemical Fractionation Versus NMR

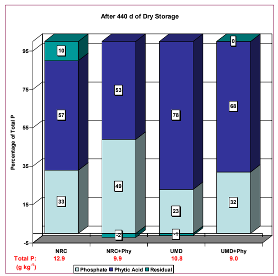


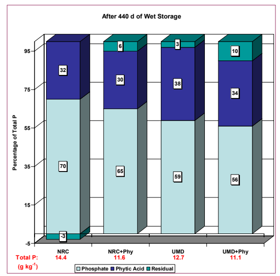
➢Solution ^{31}P NMR phosphate was significantly correlated to the sum of H_2O and $NaHCO_3$ extractable inorganic P

➢Solution ^{31}P NMR phytic acid was significantly correlated to the sum of NaOH and HCl extractable organic P

Phosphate and Phytic Acid in Broiler Litter by NMR







➢Solution ^{31}P NMR confirmed the results of the chemical fractionation:

✓Phytase hydrolyzed phytate present in the feed, making it available to the broilers and reducing total P excreted

✓Feeding closer to broiler non-phytate P requirements, in the UMD diets, reduced phosphate excretion

✓Wet storage resulted in significant hydrolysis of phytate present in the litter, significantly increasing P solubility

Conclusions

•Reducing non-phytate P supplements in conjunction with phytase use is an effective means to reduce total and water-soluble P in broiler litter

•Solution ^{31}P NMR and sequential chemical fractionation confirmed that dietary phytase hydrolyzes phytate in broiler feed, making it available to the broiler and reducing excreted phytate, without appreciably increasing excreted labile P

•Proper management to minimize litter moisture content can significantly limit increases in soluble P – thereby reducing the potential for P losses in runoff from litter-amended soils

•There was no correlation between increases seen in labile P during litter storage and diet; therefore, it is unlikely that dietary phytase continues to hydrolyze phytate during litter storage

Pens Used to Raise Broilers

Storage Study Containers

References

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Authors

J.M. McGrath, Department of Crop and Soil Environmental Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. ***J.T. Sims***, Department of Plant and Soil Science, and ***W.W. Saylor***, Department of Animal and Food Science, University of Delaware, Newark, DE 19716. ***R.O. Maguire***, Department of Soil Science, North Carolina State University, Raleigh, NC 27695. ***C.R. Angel***, Department of Animal and Avian Science, University of Maryland, College Park, MD 20742. ***B.L. Turner***, Smithsonian Tropical Research Unit, Apartado 0843-03092, Balboa, Ancon, Republic of Panama.