ilc resources

MINERAL WRITES

THIRD QUARTER 2006

CALCIUM

Feed-grade calcium products are available in a wide variety of particle sizes, from liquid suspendable products to large particle products for laying hen diets.

DICALCIUM PHOSPHATE

Both 18.5% and 21% phosphorus products are available.

SODIUM BENTONITE

Bentonite products are available in a wide variety of particle sizes suitable for any purpose.

POTASSIUM

ILC Resources has both potassium chloride (KCl) and potassium magnesium sulfate (K/Mg/S) available.

All products are available in both bag and bulk.

Broiler Chicken Study

(University of Arkansas)

2005-2006

"The effect of calcium carbonate particle size and solubility on the utilization of phosphorus from phytase for broilers"

Introduction:

Dr. Craig Coon, poultry scientist, and his Research Associate Dr. Megharaja Manangi from the University of Arkansas in Fayetteville, AR, conducted a study spanning 2005 into 2006 with broiler chickens examining the dynamics of nutritional interactions between calcium and phosphorus in the presence of dietary phytase enzyme.

Overview of Dynamics:

The addition of phytase enzyme to the feed unlocks bound phosphorus from the phytate complex present in grains and soybean meal. The monogastric *(simple stomach)* animal lacks the necessary enzyme(s) to do this naturally. Added to typical corn-soy diets, phytase allows for release of P, thus reducing the amount of supplemental P needed and also reducing the amount of P pollution to the environment. As phytase splits the bonds of the phytate complex and releases P, ionized calcium (Ca^{++}) potentially works negatively to rebind that complex. If reaction with Ca^{++} can be delayed allowing phytase to release P first, improvement in digestive efficiency and nutrient utilization would result.

Experiment:

A 28-day feeding trial was conducted using 1680 broiler chicks to evaluate the influence of feeding different particle sizes of $CaCO_3$ on growth performance and bone development (measured by tibia ash). The tibia is the "drumstick." The experiment consisted of 8 treatments (corresponding to eight different $CaCO_3$ particle sizes), each treatment replicated six times to validate impact of test results. The table at the top of page 2 shows the eight $CaCO_3$ particle sizes used.

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For additional information contact

Richard H Bristol, MS
ILC Resources Director of Nutrition and Technical Services

ILC Resources
500 New York Avenue • Des Moines, Iowa 50313
(515) 243-8106 • Fax (515) 244-3200 • 1-800-247-2133
www.ilcresources.com
richardb@ilcresources.com

Table 1. Treatment Products & Particle Size Description

Diets*	Product (Particle Size Description)	Average Particle Size (microns)	% Acid Solubility**
Diet 1-W-S	Unical-S (small granule)	300	47.0
Diet 2-W-FF	FreFlo (Blend small to large granule)	520	46.7
Diet 3-W-L	Unical-L (large granule)	800	42.2
Diet 4-A-P	Unical-P (finely ground powder)	30	74.4
Diet 5-A-S	Unical-S (small granule)	140	56.4
Diet 6-A-L	Unical-L (large granule)	760	45.3
Diet 7-A-FF	FreFlo (blend small to large granule)	390	53.0
Diet 8-A-F	Unical-F (fine coarse particle)	1300	43.4

*Diets are indicated based on the source of $CaCO_3$. "W" refers to product from *Weeping Water*, "A" refers to product from *Alden*. The letters "S", "FF", "L", "P", and "F" represent the different particle sized products.
**Refer to 2nd Qtr 2005 *Mineral Writes*

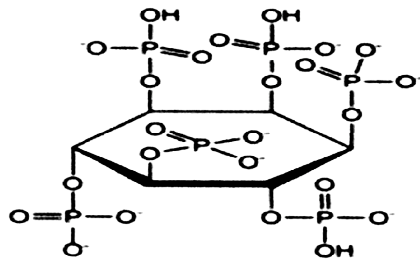
The basal diet consisted of corn and soybean meal that was formulated to contain 21.5% CP, 3025 kcal ME/kg, 0.78% Ca, 0.20% nPP (non-phytate phosphorus), with phytase added (500 FTU/Kg-Danisco Phyzyme). All treatment diets were the same except for the form of $CaCO_3$ used. Diets were not pelleted to eliminate potential enzyme destruction and pelleting problems associated with large particle treatments. Analyzed dietary values were:

Total P, % 0.45
Ca, %..0.88
DM, %..90.00
C.P., %...21.0
Gross energy, kcal/kg...................3958

Non-phytate phosphorus (nPP) was set at 0.20% to maximize the response differences between calcium sources. If diets contained too much nPP, it would be difficult to detect a significant difference in performance response and bone development – both of which are critical to the study. The study's hypothesis suggests that if calcium sources' particle sizes and solubility decrease the amount of phytic acid that forms a mineral phytate complex, then there should be a maximum response of the phytase enzyme and more available P for growth and bone formation.

Phytate structure revealed:

To understand the significance of this, we need to digress and consider how bound phosphorus exists in the phytate complex present in typical grain-soybean meal feeds. It is possible to release P with added enzymes, but also possible to rebind P with Ca rendering P unavailable to the animal but potentially polluting the environment from excess P in manure.



Phytate – abundant in plant cells; storage of Phosphorus for utilization during seed germination & seedling growth.

Phytate is abundant in plant cells and serves as a storage form of phosphate for utilization during seed germination and early seedling growth. Monogastrics lack the enzymes needed to break apart this bond. Undigested phytate in animal waste also contributes to environmental phosphorus pollution. The breakdown of phytate is achieved by enzymes called phytases. Addition of phytase in animal feed improves the utilization of phosphate from phytate. As a result, fecal phosphate excretion may be reduced by up to 50%.

Previous research findings have shown:

- **a.** Amount of Ca in a broiler diet affects the use of phytase.
- **b.** Solubility of phytic acid (phytate) in feed ingredients is affected by pH.
- **c.** Phytate P utilization is affected by Ca^{++} concentration in small intestine where insoluble Ca-Phytate complexes form.

Background and Objectives:

Supplemental phytase in feed is presently being used to help the poultry industry control phosphorus buildup in poultry waste that is used as fertilizer. Phytase enzyme lowers the phosphorus in poultry waste and supports an ecological effort to decrease phosphorus in our water supply. The amount of calcium in a broiler diet has been reported to affect the use of phytase. The solubility of phytic acid in feed ingredients has been reported to be affected by pH. It has been suggested that most phytate complexes are soluble at a low pH (less than 3.5) with maximum insolubility occurring between pH of 4 and 7. Calcium phytate complexes precipitate at pHs between 4 and 6 which is the approximate pH of the intestine. Further, the primary factor affecting phytate phosphorus utilization is the Ca^{++} ion concentration in the small intestine where insoluble Ca-phytate complexes form. Thus, the solubility of calcium in the gastrointestinal tract may have a direct effect on forming phytate mineral complexes.

The objectives of this research were to evaluate the impact of feeding different particle sizes of $CaCO_3$ (with corresponding different acid solubility values) on broiler performance and to determine their effect on phytate P decomposition at low and high pHs of 2.5 and 6.5 represented in the GI tract.

Results:

The *in vivo* (animal) study showed live growth performance was affected by feeding different particle sized $CaCO_3$. The best performance for weight gain and feed consumption was obtained in chicks fed FreFlo. Comparable response was obtained in chicks fed Unical-S. These two products have particle size profiles ranging between 100 and 400 microns. Poorest performance and highest mortality were observed in chicks fed Unical-F averaging over 1300 microns. Predictably, coarse particles were simply too large to allow enough ionized Ca^{++} to meet the bird's *calcium* requirement. On the other end, Unical-P, ranging around 30 microns, solublized Ca^{++} ions too rapidly and presumably either rebound the phytate molecule and/or were carried through the GI tract too rapidly to meet the bird's nutrient requirement for *calcium*.

Although phosphorus retention percentage was not affected by $CaCO_3$ particle size, total quantity of phosphorus intake and total quantity of phosphorus retained were significantly affected – again favoring FreFlo and Unical-S. Results also showed that the amount of tibia ash was highest for chicks fed FreFlo; thus, suggesting better bone formation.

Results from the *in vitro* (laboratory) part of the study showed significant effects of both the particle size and the interaction of particle size and pH on phytate phosphorus breakdown by phytase in releasing inorganic phosphorus.

At low pH of 2.5 (simulating stomach conditions), there was an 8% reduction in phosphorus decomposition from phytate when chicks were fed powdered $CaCO_3$ versus granular particle sized $CaCO_3$. At higher pH of 6.5 (simulating intestinal conditions where Ca^{++} ions are absorbed), there was a 15% reduction of phosphorus splitting off from phytate when chicks were fed powdered $CaCO_3$ versus larger particle $CaCO_3$. This supports the idea that finely ground $CaCO_3$ releases Ca^{++} rapidly and rebinds the phytate molecule. Although laboratory testing cannot completely compare with live animal testing, the *in vitro* experiment explains the basis for exploring the use of granular $CaCO_3$ particles with lower solubility in monogastric diets along with phytase supplementation for improved phosphorus utilization and subsequent strategic reduction in phosphorus excretion.

The results from this study well indicate that broilers may gain more from feeding phytase when also feeding granular particle sized $CaCO_3$ to minimize the solubility of $CaCO_3$ in the crop and anterior portion of the gastrointestinal tract. Lower solubility larger granular form of $CaCO_3$ may allow the phytase enzyme more access to the phytate phosphorus in the gut and provide higher phytate phosphorus disappearance in the broiler. A high percentage of powdered $CaCO_3$ solublizes too rapidly for Ca to be adequately absorbed as rate of digesta passages carries those ions through the GI tract and they end up deposited in manure droppings. However, the quickly solublized Ca ions may readily rebind phosphorus to the phytate molecule thereby negating the phytase enzyme's activity. Not only is phytate phosphorus rendered unavailable but Ca retention is deterred too. To summarize, $CaCO_3$ particles that are too small (powder) or too large (coarse) may result in lower growth performance. The desirable particle size pattern best fits FreFlo and Unical-S profiles. Coarse particulate $CaCO_3$ predictably solublize Ca^{++} too slowly and pass through the GI tract intact as $CaCO_3$. On the other hand, finely ground particles of $CaCO_3$ presumably solublize too rapidly, hindering phytase enzymatic release of phosphorus by rebinding the phytate molecule. At the same time, due to rate of passage, rapidly solublized Ca^{++} may escape absorption and be lost in the manure. Certainly these phenomena are not completely clear cut, but extremes in $CaCO_3$ particle sizes (too large–too small) do represent plausible action hindering performance.

Interpretations and Suggestions:

Are there any extrapolations that can be made from this study regarding application in other species' diets incorporating enzymatic phytase addition? One must cautiously approach interpreting data from one study's findings to other conditions and species. However, some logical questions and suggestive thoughts may well be valid.

Just how different are the digestive systems and corresponding chemistry among poultry groups and other monogastrics?

Other poultry considerations lend themselves to some obvious similarities. Laying hen pullet nutrition from chick to pre-lay would afford a distinct degree of similarity to growing broilers. Emphasis on structural development for egg production may be somewhat different than simply maximizing weight gain in broilers, but both require proper gain and skeletal development. The feeding of both species faces the common challenge to reduce ecological pollutants, such as excess phosphorus. Presumably similar dynamics exist with growing and finishing turkey production as well.

A leap to swine may not be as great as one would imagine. Swine and poultry are monogastrics. Both species have lower pH conditions in the stomach (presence of HCl to digest proteins). As digesta passes into the intestinal tract, pH raises and Ca^{++} ions are absorbed. If phytase enzymes are being fed in monogastric diets, this study's concepts may well have common implications.

Ruminants, of course, have fundamentally different conditions. Due to the symbiotic relationship with bacterial popu-

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lations in the rumen, the phytate complex in grains is broken down and P is released by that bacterial actionDefinitive research on the role $CaCO_3$ particle size plays in mineral nutrition remains incomplete. From historical monogastric studies a wide range of $CaCO_3$ particle sizes (150 microns to upwards of 1000 microns) have been reported to result in adequate growth performance. The scientific literature covers mineral particle size research from the mid '80s to early '90s. There is noticeable scarcity of additional research from this time period to the present. These historical studies are based on growth performance factors in the absence of phytase supplementation.

Today's formulating of diets to reduce environmental pollution requires balancing nutrients in a fine line hovering between adequacy and insufficiency. It becomes increasingly necessary to optimize response to nutrients supplied. If phytase is used to unlock bound phosphorus and thereby reduce the need for additional phosphorus supplementation, the importance of using specific gradation sources of calcium carbonate to insure dietary adequacy of both calcium and phosphorus becomes increasingly critical for successful performance.

No definitive conclusions can be drawn across multiple species for exact recommendations based on this study alone, but recognition of its concepts is warranted. The intricacies this study reveals in the dynamics of nutrient relationships leave one intrigued and desirous for more knowledge. Certainly, more research and further study is needed.

One last thought, however. Some things a company in the *feed-grade* calcium carbonate business has control over. Some things they don't. Commitment to quality control measures from processing calcitic limestone into consistent precise gradation $CaCO_3$ products for the feed industry is bedrock to successful business aimed at customer satisfaction. Further, commitment to constant testing of products to provide needed data to meet nutritional needs for successful livestock and poultry feeding is essential as well. Striving to sponsor meaningful research to gain more understanding about feeding $CaCO_3$ to improve nutrient utilization is also indispensable. The fundamental properties of any calcitic limestone deposit being quarried and processed unfortunately are not controllable. This research demonstrates that there are inherent differences among limestone sources. Acknowledging that truth and yet at the same time wisely managing controllable factors will not only improve understanding of feeding $CaCO_3$ but more importantly improve our customers' profitable results achieved from applying that understanding.

Dairy-White SWEET BARNLIME

Safely stored away in antiquity's file cabinet are the origins of this remarkable product. It seems to have been around since Methuselah and yet is as effective today if not more so than when introduced back in the '50s. Just what is it and what does it do? And is it strictly for dairies?

DAIRY-WHITE BARNLIME is produced from the same high calcitic limestone deposits that ILC Resources uses to produce excellent *calcium carbonate* products for livestock and poultry feeds. ILC Resources uses a unique screening and blending process resulting in two grades of DAIRY-WHITE BARNLIME. One is "regular" while the other is "coarse." Both of these distinctive products adsorb moisture, reduce odors, enrich manure and are non-caustic to animals and humans.

DAIRY-WHITE BARNLIME has been totally dried, which helps prevent slippage and injuries by adsorbing moisture where it is applied — barns, loafing sheds, farrowing houses, pet areas, horse stalls and alleyways, and poultry houses, to name just a few. Wherever moisture and footing is a problem, BARNLIME provides a solution. Slippage is reduced by large particles – especially in the "coarse," while smaller particles adsorb moisture. BARNLIME chemically neutralizes acid, thus reducing odors. And when applied to fields, the BARNLIME-enriched manure will help reduce soil acidity. Its non-caustic properties provide for safe use in any area utilized by animals and humans.

But **DAIRY-WHITE BARNLIME** is not designed for dairies only and has proven successful in a variety of animal facilities. Wherever moisture on hard surface walkways is a problem leading to injuries from slipping, BARNLIME will help. Wherever odors emit from animal waste build up, BARNLIME will sweeten the air. Wherever BARNLIME treated manure is applied to fields, soil is enriched.