ilc resources

MINERAL WRITES

FIRST QUARTER 2007

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.

Calcium Research Reviewed

Since 2003, *Mineral Writes* has reported on numerous poultry research studies pertaining to the dynamics of *calcium* nutrition affecting such diverse aspects as bone development for efficient growth and its importance in eggshell quality. These studies have involved egg production in laying and breeder hens and broiler production with implications to other aspects of poultry production and even other monogastric species and ruminants.

Mineral Writes has looked at the influence that physical and chemical properties of feed-grade *calcium carbonate* ($CaCO_3$) play in interacting with other nutrients. Calcium–phosphorus interactions—both in terms of dietary amounts as well as ratios—have been examined. Additional influence of phytase in unlocking phytate-bound P from seed grains in the presence of calcium source forms and concentrations have been reported. Inherently important to particle size of supplemental $CaCO_3$ is a measure of its actual availability based on its solubility in stomach acid during digestion. These intertwining synergies and/or antagonisms play a very key role in effectively influencing growth rate and bone development as well as reducing environmental pollution of excess phosphorus.

Mineral Writes has reported on *calcium's* role in egg shell formation. Certainly, paramount to this is the layer industry's efficient production of eggs for commercial use. However, the same dynamics are present in the breeder side of both layers and broilers and thus better understanding of layer nutrition may have implications beyond commercial egg production alone. Broiler breeders and turkey breeders alike share similarities with laying hens. For that matter, something as divergent as commercial quail farm production may benefit by this knowledge, as already evidenced by outside inquiry.

Calcium Carbonate or Limestone:

To diverge for a moment, the mineral ingredient *calcium carbonate* is from a limestone deposit – calcitic limestone. But, it is far more specific than the common reference of *limestone* which could contain as low as 33% Ca. A source this low in calcium must be labeled *ground limestone*. Calcium Carbonate must contain 38% minimum *calcium* (Ca). Another misunderstood reference to *limestone* as a feed additive involves dolomitic limestone. Dolomite is comprised of both *calcium carbonate* and *magnesium carbonate* and runs 21% Ca and 12% magnesium (Mg). Bedrock to dietary considera-

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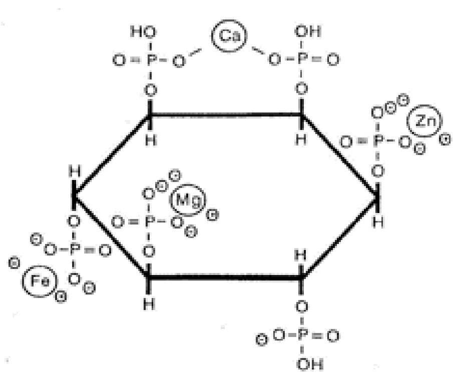
tions when balancing for supplemental Ca must be a distinct recognition of these differences.

NOTE: The author is aware of a graduate level research study that mistakenly used dolomitic limestone in its feed formulation and this critical error was not realized until after the trial work was completed. The time and expense invested in animals, feed, and personnel were wasted. Another trial was conducted with $CaCO_3$ after realizing dolomite is not the same thing. Unfortunate incident, but avoidable.

Thus, the feed industry is confronted with a legality of labeling issue by its choice of *limestone* use. However, risking improper formulation of dietary nutrients adversely affecting performance is perhaps of greater importance. ILC Resources sells calcium carbonate.

Articles previously reported in *Mineral Writes* have covered an array of $CaCO_3$ particle size gradations in different studies' treatments over a number of animal production periods targeting a variety of effects, from growth and bone development to egg production parameters. Do these studies have a common thread worthy of summarizing? For ready access to previous issues of *Mineral Writes*, search ILC Resources' website: www.ilcresources.com.



Phytate Molecule in grain seed

Calcium, Phytase, and Phosphorus:

One study (MW 1st Qtr 2003 – Chung '03 Singapore) showed that the phytase enzyme improved P utilization by releasing phytate bound phosphorus in grains. Without readjusting accordingly, diets may prove excessive in Ca, potentially increasing intestinal pH, actually inhibiting enzymatic breakdown of phytate and retarding absorption of other phytate-bound minerals as well. Phytase does improve P utilization by releasing bound P from phytate in grains, but without proper dietary adjustments to Ca,Ca could prove to become part of a problem not a solution.

In another article (MW 3rd Qtr 2005 – U Georgia Sept '05) it was shown that phytase spared negative effects of either *high Ca–low P* or *high P–low Ca* diets. The first condition resulted in depressed growth rate in broilers, while the second situation demonstrated severe TD (*tibial dyschondroplasia*). In diets balanced in both Ca and P, phytase had little effect. But, high Ca-low P diets with phytase optimized growth. This study showed that dietary levels of Ca and P were important in response to phytase.

A broiler study (MW 1st Qtr 2006 – LSU March '06) evaluated the phytase enzyme's effect on growth and intestinal transit time in diets adequate or deficient in Ca and non-phytate phosphorus (nPP). Phytase improved growth performance and bone parameters in diets deficient in Ca and P as well as diets adequate in Ca-P. Phytase also reduced intestinal transit time resulting in improved feed intake and weight gain. Reducing the need for supplemental phosphorus further reduced P excretion to the environment. Phytase released bound P but also improved Ca status as well.

In a landmark broiler study (MW 3rd Qtr 2006 – U ARK June '06) involving phytase use in diets to unlock bound P, Dr. Craig Coon's research team discovered that particle size (and corresponding acid solubility) of $CaCO_3$ source had a major impact on efficacy of performance. Larger granular $CaCO_3$ solublized slower and delayed release of Ca^{++} longer than did finely ground powdered $CaCO_3$. Slower solublized $CaCO_3$ prevented rebinding of P on the phytate molecule and thus, improved efficiency of digestion. Finely ground powdered $CaCO_3$ solublized too rapidly, resulting in poor performance. Coarse particle $CaCO_3$ solublized too slowly to allow for adequate Ca^{++} to meet needs. Small to medium granular blend of $CaCO_3$ demonstrated ideal range. In low pH of the stomach, powdered $CaCO_3$ reduced P decomposition from seed phytate versus medium to small granular $CaCO_3$. In the higher pH condition of the small intestines, an even greater *reduction* of P release from phytate was noted with powdered $CaCO_3$ versus granulars—postulating that finely ground $CaCO_3$ solublized Ca^{++} quickly and rebinds P to phytate complex. The ideal range of particle sized gradations of $CaCO_3$ must be closer associated with corresponding solubility than simply particle size alone. When similar particle size patterns from differently sourced $CaCO_3$ were compared, different results were noted. Thus, solubility plays the greater role in these phenomena.

Tying together Phytase-Ca-P:

From these four reported studies, what can be drawn together about the complexities of feeding phytase enzyme in corn-soy diets of broilers and the subsequent interactions of Ca and P on performance and efficiencies? Excess calcium in the diet inhibits phytase action and retards mineral absorption, not only of P but other minerals as well (refer to phytate molecule). Balanced diets exhibited little or no improvement, but this is misleading. Formulating diets that force unlocking of phytate-bound P with phytase enzymes to meet phosphorus requirements is well justified—both for biological efficiency of affected animals and for reducing environmental P pollution. Further, the use of phytase has been shown to speed up rate of passage through the intestines whereby greater feed intakes occur and improved weight gains are realized. Improving performance efficiency plus bone parameters help unlock these mysteries as well. Both particle size and corresponding solubility rates of granular $CaCO_3$ are important contributors to understanding enzymatic release of nutrients (P, Ca, Zn, Fe, etc) from the phytate-bound complex in grain seeds. Thus, balancing diets to achieve nutritional adequacy also necessitates additional considerations of ingredient properties, such as size of particles and chemical reactivity during digestion.

Particle Size of $CaCO_3$ affects Egg Laying Performance:

Three more studies were reported involving the dynamics of Ca particle size and solubility along with P in layer and breeder hen diets affecting eggshell quality issues and bone development.

A landmark study from the University of Nebraska poultry science department led by Dr. Sheila Scheideler was reported in *Mineral Writes* in two parts. The first part examined the optimum blend of large to fine particle size $CaCO_3$ for laying hens (MW 1st Qtr 2004 – UNL December '03). Two dietary concentrations of Ca were measured in three different programs of differing blend rates of fine (Unical-S) to large (Shell & Bone Builder) particle $CaCO_3$ over five periods of the laying cycle from pre-lay through end of lay (approximately 50 weeks total). Investigating egg production, eggshell quality, and skeletal integrity in both Hy-Line W-36 and Hy-Line W-98 strains of layers revealed that as hens age an increase in the proportion of large to fine particle $CaCO_3$ was necessary to maintain optimum performance. Differences existed among strains, but trends paralleled both. As the birds reached peak lay, they performed best at minimum 50:50 blend of large to fine particle $CaCO_3$. Continuing to end of lay cycle demonstrated best performance with an increasingly greater proportion of large to fine particles, ending at 70:30 blend of large to fine particle $CaCO_3$. Concerning the effects of dietary calcium concentrations, Hy-Line W-98 hens performed better on high calcium diets; whereas, Hy-Line W-36 hens performed well on the average calcium diet. The correlative dynamics of particle size and respective solubility values are intertwined in this study as well, even though measurements were conducted relative to particle toward <u>end of lay</u>, she needs a dietary source of $CaCO_3$ that is increasingly slower to solublize to maintain eggshell quality. This relates closely with increasing particle size but also must correspond to actual solubility of the particular $CaCO_3$ source. Like particle sized $CaCO_3$ from different sources test differently in their *in vitro* solubility values. It follows that solubility values are especially important to consider and not just particle size alone.

The second part of the UNL study examined optimum Ca and P levels in the diets of two strains of Hy-Line laying hens (MW 1st Qtr 2005 – UNL December '04). As treatment, two dietary calcium concentrations (average and high) were fed in combination with two dietary phosphorus levels (also average and high) to Hy-Line W-36 and Hy-Line W-98 birds during their entire laying cycle. Dietary Ca did not affect egg production during post-peak period. At end of lay, the larger W-98 hens produced more eggs on higher Ca while W-36 hens were unaffected by higher Ca. Higher dietary Ca improved egg weights while dietary P had little effect on egg production. Egg mass (measure of how full the egg is) was improved in both strains by higher Ca, but dietary P only affected egg mass at end of lay while higher P actually decreased egg mass. Percent shell was unaffected by dietary treatments but showed a strain effect with W-36 hens producing greater percent shell than W-98 birds. This phenomenon certainly correlates respectively with whole-egg versus breaker-egg marketing. Higher Ca produced a denser egg while lower P also tended to produce a denser egg. Scheideler explains that average P during egg production promotes better bone turnover which correlates with better egg specific gravity and shell quality. Thus, after growth, dietary P may be reduced to account for egg production alone.

Strain differences make dietary formulation important when considering Ca and P levels. Certainly, particle size of Ca source is an important factor in dietary considerations as evidenced in the first part of this study.

A collaborative broiler breeder study was reported in late 2006 (MW 4th Qtr 2006 – U ARK summer '06) examining the effects Ca particle size had on eggshell quality, bone parameters and P excretion. Eggshell quality is paramount to successful hatchable egg production. Calcium and phosphorus are also important components in maintaining skeletal bone strength for longevity of breeder hens. Similar dynamics would certainly apply to laying hens and/or turkey breeders. Dr. Craig Coon et al. sought to determine if large particle $CaCO_3$ could affect bone parameters and reduce P excretion. Large particle $CaCO_3$ (Shell & Bone Builder) in the diet versus small granular $CaCO_3$ (Unical-S) did improve both percent tibia ash and egg densities while reducing phosphorus excretions. Large particle Ca provided a metered source of ionized Ca^{++} during eggshell formation, thus alleviating demand on mobilized bone for Ca. At the same time, this reduced excess P being excreted due to less bone mobilization. How to hold large particle $CaCO_3$ in the feed

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Calcium Research *continued*

for dietary presentation is of major challenge, especially since many breeder diets are pelleted. As a follow up to our earlier report, ILC Resources received communication from a customer who routinely makes layer-breeder pelleted diets with Shell & Bone Builder. Below is their statement:

> "We are currently and have been for several years pelleting layer-breeder diets with large particle calcium carbonate in them.
>
> We had to go to a 9 mm pellet die, and do have issues with the die plugging if proper procedures are not followed. We have, however, had a marked increase in hatchable eggs. Our customer has switched their Georgia and Illinois flocks to ILC Shell and Bone Builder since our success with their local flock. When their hatchable eggs are worth a multiple of conventional egg prices, the switch has proven very beneficial."
>
> Sincerely yours,
> Edward J. Kleinwort
> St. Ansgar Mills, Inc.

Another customer formulates turkey breeder diets so that approximately half of added calcium needs come from large particle $CaCO_3$ (Shell & Bone Builder). Since instituting this scheme they have experienced improved eggshell quality.

Literature Review suggests more understanding needed:

This review of seven previously reported articles appearing in *Mineral Writes* on *calcium* and *phosphorus* illustrates some common threads of understanding, even though there are more studies regarding the complexities of phytase's enzymatic impact on P nutrition, large calcium's role in egg production issues, and the interrelationships of Ca – P on skeletal support. The intricacies of enzymatic phytase action on seed phytate P and subsequent reduction of environmental P pollution are issues that continue to be examined and new discoveries made. The few articles reviewed here only touch on the abundance of existing phytase research. The attempt here is to draw attention to the significance of calcium's role in this complex drama.

Calcium is the single largest mineral nutrient present in animals, regardless of species. Nearly half of all mineral in the body is calcium. It is not potentially a pollutant, thus, remains relatively uncontroversial. And yet, it plays many crucial parts in the overall scheme of nutrition. Most recognize its structural role as a component of bone. Many other regulatory functions require calcium, including milk production, heartbeat regulation, hormonal control, reproductive functions, nerve impulses, muscle contractions, and enzyme activation. This nutrient seems so simple and is often taken for granted.

As a component of poultry diets, both amounts and forms of $CaCO_3$ potentially play synergistic or antagonistic roles in corresponding P metabolism—especially in the unlocking of bound P from the phytate molecule of seed grains. Additionally, calcium carbonate's neutralizing properties not only affect release of ionized Ca^{++}, but will impact digestive interactions both physically (rate of digesta passage through intestinal tract) and chemically (reduction of P release from phytate if $CaCO_3$ is highly soluble). As is known, particle size of $CaCO_3$ correlates with its reactivity rate in the stomach's acid medium during digestion. Finely ground calcium carbonate's solubility rate may present ionized Ca^{++} too rapidly and thus too soon for proper utilization. However, large particle $CaCO_3$ may solublize too slowly to be of optimum benefit in growth considerations for skeletal development, but could be precisely the needed rate for other benefits such as eggshell formation.

These dynamics greatly influence a diversity of metabolic factors affecting bone formation, eggshell quality, growth, feed intake, efficiency of feed utilization and many more. The body of active research has tended to cease its interest in calcium's contribution to nutrition over a variety of species. These few reviewed articles demonstrate the significance of this nutrient's role and suggest much more information is needed.

These research articles were all poultry-oriented. Caution is always necessary when extrapolating information to other species, but shouldn't we ask if there might be cross interpretations? As suggested before, many dynamics involving growth and development among all species show similarities. Certainly, obvious differences prevail. Swine, beef and dairy hardly have eggshell quality issues. Yet calcium's role involving other structural and regulatory functions is common among all species. Swine diets use phytase to unlock bound P as do poultry. Ruminants, either beef or dairy, have need for calcium similarly to poultry, such as heartbeat regulation, hormonal control, nerve impulses and more. Particle size relating to solubility of supplemental $CaCO_3$ will impact the rate Ca^{++} is ionized and therefore its timing for proper absorption and utilization. Much of these reviewed dynamics open understanding and at the same time suggests more questions yet to be answered.

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