ilc resources

MINERAL WRITES

SECOND QUARTER 2008

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.

What calcium product should I be feeding?

ILC Resources occasionally receives inquiries about what particle sized calcium carbonate product is best suited for feeding a given group of animals. The question is relatively simple, but an appropriate answer usually is not simple. Recently, a customer asked this very question. The customer had been contacted by a college student who was doing an animal science project. The student seemed to be looking for some chart of basic guidelines. Our reply prompted more than a basic usage chart. To give a proper response, we needed to draw out varying scenarios and general feeding conditions. This article shares our response to the college student's inquiry.

This is not an attempt to change any product usage currently employed. Nevertheless, as new situations arise or applications alter, perhaps some general guidelines may have merit in future considerations.

We'll start by examining individually the three species of poultry, swine and cattle. There will be overlap, but there are differences in considerations as well.

POULTRY

Poultry probably should be divided between laying hens and others. The "others" is a broad category associated mainly with growth and encompasses broilers to pullets and even includes turkeys, in general. To start with the others, we need to realize basically what supplemental calcium does. For the most part, it simply provides skeletal development or growth. However, other dietary ingredients and supplementations also have some bearing. For example, in monogastric diets the addition of phytase enzyme to unlock phytate bound phosphorus (P) in grains and oil seed meals is common practice. Phytase unlocks the complex phytate molecule present in these energy and protein sources to release P. If supplemental calcium carbonate ($CaCO_3$) particles are too fine *(e.g. powder)*, the possibility exists that quickly ionized Ca^{++} may rebind that molecule and negate phytase's action. The University of Arkansas, under Dr. Craig Coon, conducted a broiler poultry study unlocking some of this mystery (refer to *Mineral Writes* 3rd Qtr 2006). Those research findings demonstrated that FreFlo (blend of small to large granular particles) and Unical-S (small granular particles) products resulted in optimum growth performance and mineral utilization of Ca and P. Much larger particles (Unical-F) solubilized too slowly and simply passed out before adequate utilization. Finely ground powdered $CaCO_3$ also resulted in poor growth performance, supporting the above postulation of disrupting phytase's enzymatic action on the phytate molecule.

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Reasonable extrapolation may be drawn with other monogastric considerations. Similar conditions of skeletal development and growth exist with pullets, turkeys and swine. Diets formulated for these species similarly use grain and oil seed meals. ILC Resources has recommended FreFlo or Unical-S for these applications for some time. From more historical calcium studies back in the '80s and early '90s, we know a range of particle sizes encompassing Unical-S to FreFlo and even stretching to Unical-L (large granular particles) are all appropriate for these applications.

When we consider the laying hen (this would include breeder flocks for layers, broilers, or turkeys), we are introducing yet another significant element. The gizzard in the GI tract of adult poultry evolved to allow deposition of grit and small stones that grind up seeds that birds eat in the wild. That action is not as important today simply due to our processing of feed ingredients. However, there remains an element of usefulness to the action. More importantly has been the realization that large particle calcium also will deposit in the gizzard. It is bathed in the gastric juices of the stomach, principally hydrochloric acid (HCl). Large particle, low solubility $CaCO_3$ then slowly releases ionized Ca^{++} over a longer period of time, predictably during non-feeding nighttime hours when eggshell formation is most dominant. Therefore, feeding the larger particles of Shell & Bone Builder (largest particulate) or Unical-F (second largest particulate) or a combination of these two—called Shell & Bone Builder Blend—makes sense. Larger particles of grain or other organic matter ingredients are ground up in the gizzard by action of the large particles of *grit-type-rock* ($CaCO_3$ in this case). More significantly, a slower solubilizing steady source of Ca^{++} is available for egg shell formation. Thus, layer operations will use products from this category for egg shell formation along with smaller granulars (FreFlo or Unical-S or even Unical-L) for growth and maintenance in their dietary formulations.

SWINE

Swine follow a similar scenario to broilers, pullets and turkeys, which is why we recommend the granulars – Unical-L, Unical-S or combination FreFlo. Each product will solubilize adequately and furnish Ca^{++} as needed to meet dietary requirements. Rate of digesta passage through the GI tract tends to dictate that too large a particle of $CaCO_3$ passes through un-solubilized and ends up in the manure. Thus, Unical-F or larger is not advisable. On the other hand, the powders (Unical-P or *ultrafine* Unical-UF) solubilize rapidly, and ionized Ca^{++} may pass through the GI tract and end up in the manure before absorption and utilization. Also, rations with phytase are compromised due to quickly solubilizing Ca^{++} potentially rebinding the phytate molecule.

CATTLE

Cattle are somewhat different. To be a bit more precise we have split beef and dairy in this consideration, mostly due to predictable differences in how they are generally fed.

BEEF CATTLE

Beef cattle during feed-out will perform well with $CaCO_3$ particle sizes ranging from powders to large granular size (Unical-UF to granulars as large as Unical-L). Ruminant studies have shown that finely ground $CaCO_3$ powder enhances starch digestion. In support of this action, feedlot conditions that feed a "liquid feed" require finely ground powdered $CaCO_3$ (Unical-UF) to remain suspended in the liquid medium. On the other hand, either pelleted or meal dry supplements seem to suggest granular use, and they do work well. With beef cows and other pasture grazed cattle, larger granular $CaCO_3$ is called for. Some free-choice minerals being formulated are actually incorporating as large a particle size as Unical-F. This is mostly due to handling characteristics and maintaining homogeneity of particle size among other mineral ingredients in the mix. Larger particles in free-choice minerals tend to withstand elemental exposure to wind and rain better than smaller particles.

This all adds up to a wider range of possible scenarios with ruminants for two fundamental reasons. One is that the action of microbial fermentation in the rumen allows for adequate release of P from the phytate molecule; thus, enzymatic phytase is not needed. Potential rebinding by highly soluble $CaCO_3$ does not appear to be of concern. Second, rate of passage in the ruminant GI tract is generally slow enough to allow sufficient time for Ca^{++} to solubilize and be properly absorbed.

Our bias would suggest caution with the use of large particulate Unical-F in cattle feeds. The potential for large particles to pass through the GI tract and be excreted as un-solubilized $CaCO_3$ is questionable.

DAIRY CATTLE

Dairy cows tend to follow the similar conditions as beef cattle. Where dry supplementation is used the granulars are probably the products of choice. Another important consideration with dry supplementation for dairy (and other species) is use of pelleted feeds. Smaller sized granular products (e.g. Unical-S) tend to cause less friction being pushed through pellet dies and allow for

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Potpourri of Poultry Calcium Studies

Recently two research articles were published in professional journals dealing with calcium nutrition issues in poultry. One studied heat stress in laying hens, which had an effect on calcium intakes. The second study examined factors affecting peak hatchability in broiler chicks, which included egg shell quality issues influenced by dietary calcium. Both studies help further define the importance of calcium nutrition.

Heat Stress on Egg Production

The winter 2007 edition of *Journal of Applied Poultry Research* contained "Differential Effects of Heat Stress in Three Strains of Laying Hens." Conducted at the University of Nebraska under Dr. Sheila Scheideler's direction, the study targeted heat stress factors impacting reproductive performance in three strains of Hy-Line laying hens (Brown, W36, and W98). Effectively combating heat stress in laying hens is of major concern to the laying industry during hot summer months.

Hens were initially acclimated to 72°F for two weeks and then exposed for another two weeks to heat stress at 95°F, followed by an additional two-week recovery period at the initial 72° F. Production parameters (egg production, feed intake, egg quality measurements, and mortality) and intestinal calcium uptake were measured along with other factors.

This study examined which strain of hens was most successful in maintaining production through the heat. Strains of bird by temperature interactions were measured for egg production, feed intake, shell thickness, egg specific gravity (density) and yolk weight. Notably, the least severe effects were observed in the W98 strain. The W36 strain was intermediate for egg production and feed intake during the trial. Both the Brown and W36 birds were equivalent for egg shell thickness, egg specific gravity and yolk weight, however. Predictably, egg, albumen and shell weights were reduced by heat stress.

Partial explanation lies in the observation that intestinal *calcium uptake* was also reduced during heat stress. This is not just a simple phenomenon of reduced feed intake resulting in less calcium consumed. Physiologically, heat stress affects various aspects of calcium metabolism, including a reduction in free ionized Ca^{++} in the blood. In order to produce egg shells, free ionized Ca^{++} reacts with $CO_3^{=}$ to form $CaCO_3$ into shell. This mechanism is dependent on acid-base balances converting CO_2 to HCO_3^{-} to $CO_3^{=}$. Exposure to heat precipitates respiratory alkalosis. *Respiratory alkalosis* results from hyperventilation leading to decreased plasma carbon dioxide concentration. This leads to decreased hydrogen ion and bicarbonate concentrations. The interrupted reaction impairs eggshell formation. So lowered feed intakes during heat stress reduce calcium consumptions. Additionally, heat stress reduces ionized Ca^{++} uptake into blood. Also, limiting levels of $CO_3^{=}$ to react with Ca^{++} further reduces eggshell formation. Added together these three factors affect both egg production and egg quality, including shell thickness, egg density and yolk weight. Altered acid-base balance plus reduced intestinal calcium uptake during heat stress compound to lower egg production and quality of eggs.

Managing the birds to minimize these negative effects is the challenge for laying operations. Choice of bird strain may provide some answers, but managing flocks to optimizing feed intake while minimizing effects of heat internally are vital. Reducing mortality and maintaining quality egg production under these circumstances can be helped by proper facility ventilation, adequate water, cooling mechanisms, and, where appropriate, dietary alterations to lessen heat increments and maintain a balance of nutrients. **Calcium** plays a role.

Peak Hatchability Affected

Findings published in the *International Hatchery Practice – Volume 22 Number 5* May 2008 came from Dr. Emma Fleming, technical transfer manager, Aviagen, Newbridge, Midlothian, Scotland, UK.

Achieving good hatchability among breeder hen flocks is critical for economic production of broiler chicks. Aviagen, the world's leading poultry breeding company in both broilers and turkeys, has a number of wholly owned operations across Europe, the USA and Latin America, and joint ventures in Asia, Europe, South Africa and Turkey. In 2005 and 2006 Aviagen's staff became aware of field data indicating a depression in hatchability among their European flocks showing symptoms of poor egg shell quality and yolk membrane abnormalities. Subsequently, a widespread investigation of Aviagen flocks in several European countries was launched.

To understand the reasons for variability in hatch, investigators surveyed breeder health, feeding and management practices among the European flocks. Flocks were categorized according to hatchability and labeled as *best, middle and worst flocks*. Measured parameters included body weights at strategic ages, feeding levels and age of photo-

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stimulation. Interestingly, the most critical of these was achieving the correct weight gain between 15 and 23 weeks of age, which is essential for proper reproductive development. Failure to achieve appropriate weight gains adversely affected growth and ovarian development. As birds moved into subsequent egg laying activity, this negative impact could not be made up after sexual maturity.

Aviagen findings demonstrated that "achieving an appropriate weight at photo-stimulation is important to ensure birds have achieved properly synchronized sexual maturity and optimal reproductive performance." All three groups were fed diets that were low in energy. The *best hatching flocks* received diets which had higher fat content. Fat content not only supplies concentrated energy necessary for growth, but lipids are essential for yolk synthesis. Dietary mineral levels were also monitored. Phosphorus levels were similar in all three groups, indicating P was non-contributory to problems. However, the *best hatching flocks* received a diet with a higher calcium level. Aviagen recommends 3% dietary calcium levels and 0.35% available phosphorus concentrations. Higher levels of phosphorus tend to reduce egg shell quality. Adequate calcium levels in the diet are important for both shell quality and hatchability.

This investigation revealed two critical components necessary for maximizing flock production and hatchability: diets of higher fat content to meet targeted growth goals for sexual maturity and higher **calcium** concentrations to improve egg shell quality.

Both heat stress and hatchability issues are complex and defy simple solutions. Calcium does play a significant role in both. Ensuring dietary adequacy of **calcium** is one part of the solution.

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longer wear on milling equipment. The diameter of pellets being made influences this too. A large pellet or even a cube allows for use of the larger granular $CaCO_3$ due to less friction and scouring of walls on larger diameter pellet dies. Smaller diameter pellets demand small sized granular material or possibly even powder to reduce possible friction and scouring of dies. From a mill handling perspective, however, powders pose definite problems with flowability. These are situations that may well dictate which product should be used regardless of species. Because ruminants can use a rather wide range of particle size $CaCO_3$ many product choices exist when determining what is best suited to particular situations. In summary, for ruminants (beef and dairy), the choices of $CaCO_3$ particle sizes range from powders (Unical-UF) to large granulars (Unical-L), with FreFlo and Unical-S in-between. All perform well nutritionally.

Ca:P Ratio

A current situation with beef and dairy in particular may warrant pause for attention, but this concern has nothing to do with particle size of $CaCO_3$. With increasing use of ethanol by-products, essentially DDGS or WDG, more calcium may be needed in diets to balance out a proper Ca:P ratio. Dietary P concentrations are elevated due to high feeding rates of these by-products which are high in P levels. While all diets need some supplementation to meet dietary requirements, high use of ethanol by-products will create demand for even greater amounts of supplemental calcium to meet the 2:1 ratio. That's not said in order to promote increased usage of ILC Resources' $CaCO_3$ products, but rather to emphasize the importance of maintaining dietary nutritional balance.

This is a rather lengthy response to a simple question for two reasons. First, simple recommendations without properly establishing their foundations are not a responsible answer. Second, this question was asked by a student. Our reaction was to help educate the student, not just give a simple table of product usage by species.

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