ilc resources

MINERAL Writes

SECOND QUARTER 2010

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
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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.

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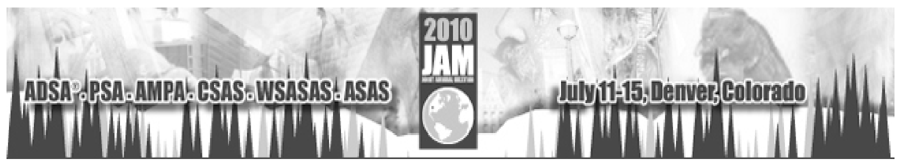
Calcium and Phosphorus called up on stage…

Even snippets of research can give us glimpses of understanding as we unlock mysteries. On the other hand, glimpses may stimulate even more questions and reveal how much bigger the mysteries actually are. Every year animal scientists from academia and industry making up the *Federation of Animal Science Societies (FASS)* gather to share their research and exchange ideas. FASS membership includes ADSA (dairy science), ASAS (animal science – monogastrics & ruminants), PSA (poultry science) and others. They will come together in mutual interest this year at the 2010 Joint Annual Meeting in Denver, Colorado July 11-15. An advanced peek at this year's scientific papers to be presented was electronically sent out to the membership in late June.



Interestingly, the collection of presentations contains a potpourri of calcium research among a vast array of other technical studies. Several studies deal with swine and laying hens. A brief look at three of these studies reveals some ideas that are worth pondering.

<u>Swine</u> –

The Ohio State University (Columbus, OH) will present a study titled **Dietary calcium and phosphorus and organic and inorganic trace minerals on nursery pig growth performance.**

This study evaluated the effects dietary calcium (Ca) and phosphorus (P) levels have on trace mineral usage. Effects were measured by postweaning growth performance and monitoring of blood plasma minerals. Two diet concentrations of Ca and P (Ca:P) and five trace mineral (TM) treatments were administered to nursery pigs. Ca:P treatments were <u>low</u> (0.80% Ca–0.65% P) or <u>high</u> (1.10% Ca-0.91% P). TM treatments were from organic or inorganic sources and were either at a lower concentration (15 ppm Cu, 15 ppm Fe, 10 ppm Mn & 140 ppm Zn) or twice that level. The fifth TM treatment was with no TM supplementation in diet; all minerals were considered indigenous (basal). TM treatment affected pig body weight from three weeks of age onwards with the basal diet resulting in lighter weight pigs. The basal diet also showed lowest average daily gains, average daily feed intakes (ADFI), and G/F (gain to feed ratio). Inorganic sources of TM treated diets revealed greater ADFI for the entire trial. Low Ca:P treatments reported greater plasma P and Zn than high Ca:P. There were no Ca:P interactions for any blood constituents. The abstract summarized that pigs fed inorganic TM had greater feed intake and hemoglobin concentrations … while high Ca:P levels actually reduced plasma P and Zn.

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This is an interesting piece of research. The study illustrates certain intricacies of dietary mineral interactions. It suggests that over-formulating diets in an attempt to achieve greater absorption and utilization of a specific nutrient may well fail to achieve desired results and perhaps show antagonism with other minerals in the process, such as high dietary calcium, which then forces an increased requirement for zinc. This phenomenon was known as long ago as mid 1950s. Other studies into the 1960s showed increased Ca and P uptake for greater bone mineralization, but also at the expense of retarding Zn and other TM nutrient utilization. Revisiting historical research to determine more closely such dietary nutrient effects seems well warranted, however. Today's swine feeding is dramatically different than that of 40-50 years ago. Ingredients may be different, and feed additives are certainly different, but swine genetics are also vastly different. We may not need to re-invent the wheel completely, but perhaps we should understand more fully what the wheel is.

Swine –

Another swine study will be presented by researchers from the California Polytechnic State University (San Luis Obispo) that examined **Effects of altered calcium and phosphorus intake on growth performance and bone characteristics in growing pigs.**

"A two-stage growth study was conducted to examine effects of altered calcium (Ca) and phosphorus (P) levels on growth performance and bone characteristics in growing pigs." Stage one was a two week trial feeding approximately 50 lbs pigs a corn-SBM diet with either NRC (control diet) or 120% NRC (treatment diet) levels of Ca and P. No effects on ADG or Ca and P content in leg bones were observed. The second stage was a four week trial following the first by randomly allotting pigs from trial one to be fed one of three diets: 1) a corn-SBM diet as control (0.62% Ca, 0.54% P), 2) same corn-SBM diet with 0.74% Ca, 0.63% P or 3) a similar diet as control but with 10% soybean hulls to decrease energy concentration. As predicted, added soyhulls increased feed intakes as pigs ate to fulfill energy demand, thus also increasing Ca and P intake compared with control, but similar to pigs fed the high Ca and P diet. Pigs from both diets with higher Ca and P intakes had greater average daily gain (ADG) compared with pigs fed the control diet. Although trial one showed no differences in both ADG nor Ca and P in bones, the second trial did. Increasing intakes of Ca and P in trial two by either higher dietary concentration of Ca and P (Tmt diet 2) or by higher feed intake resulting in more Ca and P ingestion (soyhulls Tmt diet 3) tended to increase bone weights of ribs, legs and feet. Those bones were higher in ash content, primarily Ca and P versus control group pigs. They concluded that mineral content of specific bones increase differently to increasing levels of Ca and P intake in growing pigs.

One wants to ask why this apparent discrepancy exists in the two phases of this study. The first stage fed diets with two concentrations of Ca and P and saw no differences in growth rate or bone mineral deposition. The second phase mimicked the first and noted differences both in daily gains and in bone deposition of Ca and P. Perhaps additional research will further elucidate this issue. But there may be some ideas to speculate on and offer innovative suggestions. All diets in both stages of this study stayed very close to an ideal 1.2:1 ratio of Ca:P. Stage one confirms the need to formulate diets to meet requirements but not provide excess overages of mineral that may potentially add to environmental concerns of phosphorus pollution. But then stage two apparently refutes that concern by observing greater performance of growth and stronger bone structure achieved by higher intakes of both Ca and P. Two to six weeks difference in age and maturity between stage one pigs and stage two pigs may impact nutrient metabolism and utilization. These seemingly conflicting dynamics suggest need for additional study and more in-depth monitoring to gain increased understanding.

Laying Hens –

The University of Saskatchewan (Saskatoon, CN) will present a paper titled **The effect of calcium and phosphorus supplementation on production traits of laying hens.**

Previous research from this team found that short term feeding of high levels of calcium (Ca) could increase bone mineralization. This response may benefit bird welfare by reducing cage layer fatigue and bone breakage. To test this, research investigating the relationship between Ca and available phosphorus (AP) was completed to determine the effect of increasing levels of these minerals on laying hen performance. Rations were fed in four phases from 19-31, 31-43, 43-55, & 55-67 weeks of age. All hens were fed the same diet in the first phase. The remaining phases consisted of four varying levels of Ca and three levels of varying AP. Overall, level of Ca and AP inclusion had no effect on hen-day egg production, egg quality, egg weight, egg specific gravity, feed intake, feed to egg mass ratio or bird mortality. Hens fed higher AP revealed poorer feed efficiency due to reduced egg production later in the cycle. There was a trend for higher mortality due to cage layer fatigue in low Ca and low AP diets. As such, no significant interactions were observed between level of Ca and AP supplementation.

Once again, dietary adequacy remains important for maintaining performance, but to exaggerate nutrient levels in an attempt to correct structural problems in the hen must be approached with caution. Even if adverse effects don't occur, over fortifying is likely to be expensive. In the case of phosphorus this could be detrimental both economically and environmentally. It is known that particle size of supplemental calcium has a bearing on dietary phytate phosphorus utilization and affects growth performance. Nutrient interactions of Ca and AP may not be significant, but ingredient characteristics could perhaps alter interactions either positively or negatively.

Final Comment --

As this year's papers are presented and academia and industry dialog with each other and exchange ideas, perhaps much more will be revealed. When more is exposed, we may have the opportunity to answer more questions. For now, it is most gratifying to see that such basics in macromineral nutrition as calcium and companion minerals are receiving a resurgence of interest. Rightly so.

Broiler Breeder Hen Studies – Ca:P dynamics influence beyond just egg production

Unlike laying hens, eggs from broiler breeders must fulfill the requirements of the embryo to achieve optimal growth in the developing chick. Thus, not only must the hen's nutritional requirements be met for skeletal integrity and other physiological needs including special demands for egg production, but for her subsequent progeny's success too. Comparatively, laying hens produce eggs for food while broiler breeder hens produce eggs to hatch into broiler chickens for meat consumption. Both types of hens share commonality of egg production, but particular differences in end results because breeder hens require additional considerations.

Recently a series of experiments was conducted at the University of Arkansas (UARK) which examined dynamics of calcium and phosphorus requirements of the broiler breeder hen. This series encompasses one background study and two more recent trials which reveal noteworthy findings for contemplation.

Background Study:

In 2006, M.K. Manangi conducted a study under direction of Dr. Craig Coon (UARK) titled – **Calcium particle size effects on excreta, and urinary Ca and P changes in broiler breeder hens.** *(Refer to 4th Qtr 2006 Mineral Writes)*

The study's two different calcium particles sizes were furnished by ILC Resources and were large particle Shell & Bone Builder (average particle size 3000 microns) and Unical-S (average particle size 190 microns). {Particle size profiles were analyzed by *Laser Diffraction* – Sympatec HELOS analyzer}

In a six-week trial, thirty-week-old broiler breeder hens were fed a standard broiler breeder diet supplemented with either large particle calcium carbonate ($CaCO_3$) or small particle $CaCO_3$. The researchers observed the tendency to reduce P excretion, improve P retention, increase Ca retention, increase tibia ash, and increase egg specific gravity by feeding large particle versus small particle Ca. This trial concluded that further research was needed in order to evaluate effects of large particle Ca on P retention with different levels of dietary P.

Optimum non-phytate phosphorus (NPP) in broiler breeder hen diets – First Study:

A study conducted by R.D. Ekmay at UARK under the direction of Dr. Craig Coon was reported in 2009 titled – **An examination of the P requirements of broiler breeders for performance, progeny quality, and P balance 1. (*Defining*) NPP.**

The UARK researchers set the course of this study by acknowledging "...the environmental concerns of P run off have added extra incentive into investigating reduced P intakes."

The effects of reduced dietary non-phytate phosphorus (NPP) on broiler breeder performance, progeny quality, and P balance were examined in a 40-week production trial All diets were the same except for the five P treatment levels of 0.2% - 0.4% NPP in increments of 0.05%. Production performance, eggshell quality, parental & progeny skeletal structure, and P balance were monitored. Shell quality remained high for all treatments. Total egg production, egg numbers and egg weights were not negatively affected by lowering NPP to 0.20%. Dietary NPP did not negatively impact hatchability, or subsequent progeny performance. Day-old and 21-day-old progeny weights plus progeny bone quality traits were comparable regardless of treatment. Bone quality was measured by tibia ash and bone breaking strength at 21-days of age.

Total P retention percentage decreased with increasing dietary NPP concentrations, although absolute P retained did increase with increasing dietary NPP levels. The amount of P deposited into the egg was not different among treatments. Ekmay affirmed that NPP intake as low as 0.25% is sufficient to support breeder hen performance & progeny

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performance. He stated, "Breeder hens are able to maintain their performance by mobilizing bone reserves to meet demands of egg formation and utilize dietary sources to replenish these reserves."

Further, the study decided that "The increased amount of total excreta P for breeders fed diets containing increasing dietary NPP may be of environmental concerns as well as a financial concern and serious considerations should be made at reducing dietary NPP inclusion."

This trial demonstrated that combined breeder production & progeny performed well with less NPP intake than present levels the industry is feeding.

Calcium interacts with NPP – Second Study:

As a follow up study, Ekmay/Coon (UARK) conducted and reported another trial titled – **An examination of the P requirements of broiler breeders for performance, progeny quality, and P balance 2. Ca particle size.**

The effect calcium carbonate ($CaCO_3$) particle size in the diet had in conjunction with dietary non-phytate phosphorus (NPP) concentrations was monitored in broiler breeder hens as measured by production performance, skeletal integrity and Ca/P balance. Two $CaCO_3$ particle sizes were fed and five levels of NPP were utilized. The two particle sizes of supplemental calcium (Ca) were either large particle (3500 microns – 38.5% acid solubility) or small particle (185 microns – 58.8% acid solubility). *Both $CaCO_3$ products were furnished by ILC Resources and are identified as Shell and Bone Builder for large particle and Unical-S for small particle.* Five NPP treatments consisted of 0.2% - 0.4% NPP in increments of 0.05%. Egg production, egg specific gravity and egg weights were monitored through 40 weeks of age, and tibia strength was measured at 45 weeks of age.

Phosphorus (P) retention was investigated at 31 wks of age to determine Ca/P balance. Egg weights were higher on 0.30% & 0.40% NPP. Feeding large part $CaCO_3$ resulted in heavier egg weights than with feeding small particle $CaCO_3$. Egg specific gravity (measure of egg density) was not affected by particle size. However, lower NPP concentrations showed higher egg specific gravity results. Bone breaking strength was not affected by Ca particle size or NPP level. Particle size of Ca did not affect P retention. Deposition of P into the egg was not affected by dietary P. However, Ca particle size influenced the amount of P deposited in the egg. Large particle Ca increased the amount of P in the egg independent of dietary P concentration. Closer examination of P retention in large particle Ca diets versus small particle Ca diets showed large particle Ca increased P retention in the hen, but small particle Ca showed no response to increasing NPP in the diet. The phenomenon seems age dependent in favor of younger hens (31 weeks of age versus 52 weeks of age).

The researcher stated, "Hens on a diet that included large particle limestone deposited more egg P compared to hens on a diet consisting of small particle limestone at 31 weeks. Mechanism by which P is deposited into the egg is poorly understood. Large particle Ca may limit the large imbalances caused by continual bone turnover on P homeostasis and optimize conditions of P incorporation in the young hen. The improved P retention seen with large particle limestone may provide additional P for incorporation into phospholipids and phosphoproteins."

Ekmay summarized the evidence from this study by suggesting that Ca particle size, dietary NPP, and possibly age all influence Ca and P retention.

Coon's personal conclusion: "The most interesting part of the work is we couldn't increase the P content of eggs by feeding more P but we could increase the P in eggs approximately 20 mg by using large particle limestone. We do not know how it is doing it and it seems to be mainly with young breeders."

Drawing from all three studies is a mounting sense of the interdependence of Ca and P in satisfying requirements for egg production in the broiler breeder hen. Not only does this hold true for her physiological needs, but extends to her progeny through improvement in the egg itself beyond simply eggshell quality. Furthermore, we see by this series of work that influential effects of Ca/P extend beyond contributory nutrients alone to include physical properties of supplemental sources. Supplemental Ca particle size dynamics have been well documented regarding eggshell quality issues in both broiler breeder and layer hens. These current studies reveal that those dynamics extend further to include improved quality within the egg itself for the progeny. In the hen, much demand for Ca/P is needed, of course. To promote sound skeletal development and maintenance, adequate Ca/P intake and utilization must occur. In addition to this intricate homeostasis is the hen's high demand for Ca in making eggshells during egg production. If demand comes from mobilizing Ca from bones alone, much bone P is depleted as well. Increasing dietary P to address that depletion is clearly not a viable answer, though. At the same time, deposition of P into the egg itself is not successfully accomplished by simply increasing dietary P intake. These studies have demonstrated that egg production and quality can be met by actually reducing the dietary P intake while feeding large particle Ca. By so doing, environmental concerns over P pollution are reduced as well. Finally, by manipulating particle size of supplemental Ca, improvement in P utilization is achieved and better bone dynamics are maintained. Plus, Ca needed for eggshell formation is optimized. It is yet not understood exactly how large particle Ca increases P uptake in the egg for improved progeny, but this study shows that it indeed does. For now, that is enough. This is very exciting news to build upon!