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MINERAL Writes

FOURTH 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
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.

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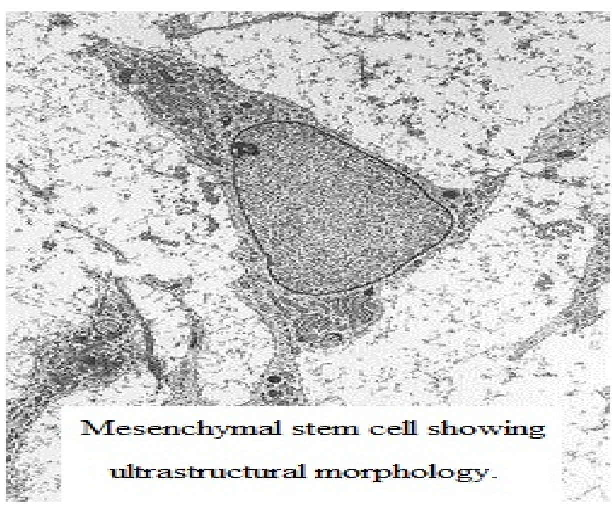
Calcium builds bones, but how?

Calcium builds strong bones and teeth in all species of livestock and poultry. Good eggshells in laying hens depend on proper supplemental calcium too. In addition to these basic functions, calcium is needed for heart beat regulation, muscle contractions, nerve impulses, enzyme activation and milk production to list a few. These we've known for a long time.

Last summer at the joint ASAS/ADSA/PSA annual meeting in Denver another research abstract was presented furnishing additional insights into calcium's metabolic role in bone formation and development, focusing on the neonatal pig. A team of researchers from North Carolina State University at Raleigh presented a paper reporting ***Dietary calcium affects neonatal bone development and mesenchymal stem cell activity.*** We understand that calcium (Ca) is a major part of bones, of course, but *stem cells*?

Before looking at this research, we need to first grasp a few points about bone formation. How do mesenchymal stem cells fit into early bone formation? For that matter, what are mesenchymal stem cells (MSC)?


Mesenchymal stem cell showing ultrastructural morphology.

(Continue Pg 2)/3

MSC are part of the complex development of early embryonic growth. MSC can differentiate into a variety of connective tissue cells including osteoblasts (cells that form new bone), adipocytes (fat cells) and chondrocytes (cartilage cells). Osteoblasts make bone by building a protein matrix called collagen that becomes mineralized. Bone mass is maintained by a balance between the activity of osteoblasts that form new bone while other cells (osteoclasts) break down or dissolve the bone. These cell names begin with *osteo* because that is the Greek word for bone.

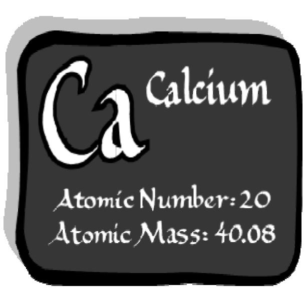
Osteoblasts build new bone made up of collagen and other protein controlling calcium and mineral deposition. When osteoblasts have finished filling in a bone cavity, their cells become flat and look like pancakes. At this stage osteoblasts line the surface of the bone, and regulate passage of calcium into and out of the bone. Further, they respond to hormones by making proteins that activate the osteoclasts.

Osteoclasts are large cells that dissolve the bone. They come from the bone marrow and are related to white blood cells. They are found on the surface of the bone mineral next to the dissolving bone. This is important in that cracks occurring in the bone matrix signal osteoclasts to be directed to those sites for dissolving of the bone to be reformed and strengthened again by osteoblasts into new bone cells.

The dynamic process of bone formation beginning in the embryonic stage of development and continuing throughout life is far more complex than the above abbreviated explanation. However, grasping the basic pathway of unspecialized embryonic cells forming into specific bone tissue cells that regulate living bone may suffice for this discussion.

The North Carolina researchers examined the effects of neonatal Ca nutrition on bone integrity, endocrine parameters and mesenchymal stem cell activity. Newborn pigs were fed in pairs either a Ca adequate (Ca^+) or a 30% Ca deficient (Ca^-) liquid diet for 18 days. Growth rate and feed efficiency were the same for each dietary Ca levels. Both groups of pigs grew at a similar rate as sow-reared pigs. However, the Ca deficient group did experience both a reduction in bone mineral density and bone bending strength. Regarding endocrine effects, the researchers anticipated an increase in plasma parathyroid hormone (PTH) levels due to Ca deficiency which did occur but not until the end of the study. When calcium concentrations fall below the normal range, a steep increase occurs in secretion of PTH. Surprisingly, dietary Ca level did not affect plasma Ca or vitamin D concentrations throughout the study. However, Ca^- deficient diets reduced the proliferation of MSC isolated from bone marrow by approximately 50% versus diets of Ca^+ adequacy. Further, *in vitro* experiments with blood samples taken from baby pigs fed either a Ca^+ adequate diet or Ca^- deficient diet demonstrated a dependency of MSC activity on calcium for proper proliferation. This study's "…results indicate that neonatal restriction of Ca nutrition is crucial for bone integrity via programming of MSC." These findings put forward that early life dietary calcium restriction may have long-term negative effects on bone integrity by means of its effect on lowering *mesenchymal stem cell* activity.

What does all this mean as we ponder these findings? Certainly, calcium is a necessary structural component in bone development and, therefore, proper growth in pigs. But this study demonstrates how vital calcium is in the programming of stem cells in early life that not only influence bone integrity, but other cells such as adipocytes that primarily make up adipose cells that specialize in storing energy as fat or chondrocytes making up cartilage. Dietary calcium sufficiency increases activity of mesenchymal stem cells forming into these tissues and dietary insufficiency of calcium retards this activity. Osteoblasts building strong bones, adipocytes storing energy in fat cells and chondrocytes making cartilage to cushion the impact of muscle and joint movement all start from healthy functioning mesenchymal stem cells. An important factor in healthy MSC activity is adequate calcium intake in early life. Naturally, these pathways are both intricate and complex, but calcium emerges as a significant part of this picture.



Calcium Effects on Egg Strength in Conventional vs. Furnished Cages

Conventional Cage

Furnished Cage

Conventional battery cages for housing laying hens have served well for promoting hygiene and facilitating management, along with reducing aggressive behavior. However, controversy has arisen concerning these cages' negative effect on hen welfare. Issues of unease have been voiced over battery cages limiting physical space and discouraging innate behavior of hens resulting in restriction of movement and exercise contributing to skeletal fragility. Impractical alternatives such as aviaries and free-range conditions may alleviate some of these negative impacts on hen welfare, but present additional adverse exposure. Predator activity, unhealthy exposure to diseases and exposure of eggs to unsanitary conditions may be detrimental to hen welfare as well as the food safety value of resultant egg production. Yet another system of furnished cages is receiving popular attention perhaps worth consideration. One such design of furnished cages employs traditional 6-hen battery cages, but modified into 2,3-hen cages with installed perches plus a nesting box for egg laying (refer to above images). With this brief overview of two housing systems, are egg quality issues affected from one housing condition to another? Should additional nutritional considerations be factored into maintaining production of quality eggs? A comparative study conducted examining environment, well-being, and behavior of the laying hens in these two housing systems may help provide some answers.

A study was reported from Finland by a team of researchers encompassing *food research, animal production research and animal disease and food safety research.*

Continue Pg 4

The trial was reported in the November 2010 issue of Journal of Poultry Science. The study was titled **Effects of calcium diet supplements on egg strength in conventional and furnished cages, and effects of 2 different nest floor materials**. This report will key in on dietary calcium effects and cage types as regards the study's findings.

Lohmann Selected Leghorn pullets were housed in either *Furnished Cages (FC)* or *Conventional Cages (CC)* at 17 weeks of age. The experiment began when the hens were 21 weeks of age and lasted for 52 weeks. The hens received 1 of 2 dietary treatments during the experiment. The treatments were a normal supplemental limestone (**NL**) diet of 3.7-4.0% calcium (Ca) or an elevated supplemental limestone (**HL**) diet of 4.4-5.0% Ca. Each dietary treatment consisted of 3 feeds fed for 3 consecutive feeding phases. "The feed energy and protein contents were decreased and the calcium content was increased in stages from one feeding phase to the next." The limestone (or $CaCO_3$) consisted of 96% of particles with diameter in excess of 1000 microns (micron = 1/1000 millimeter). Feeds were mixed and pelleted and fed ad libitum.

Findings:

Hens on the HL diet were lighter at 72 weeks of age than those on the NL diet. Comparatively, the HL diet increased the number of eggs versus NL diet, but total egg mass produced was not significant. Diet had no significant effects on egg quality variables. At end of lay, there were no differences on tibia-breaking strength or egg specific gravity among birds on either dietary treatment. Cage type did favor hens in CC vs. FC in laying rate over the 52-week laying period. Assessing egg quality, FC eggs were of lower specific gravity than CC eggs, and FC eggs had higher Haugh values (*unit for describing egg freshness*) than did CC eggs. Cage type effect on tibia-breaking strength was not significantly different among hens.

Despite numerically lower feed intake, the hens on HL diet laid more eggs than their counterparts on the NL diet. The researchers acknowledged that higher dietary calcium carbonate supplementation has an alkalogenic effect (due to CO_3^-) enhancing laying rate, shell strength and specific gravity. Higher laying rates were observed on HL diet, but no significant effects were seen on shell strength and specific gravity. Laying rate effects due to cage type slightly favored CC over FC. This study revealed no differences in shell-breaking strength between cage types, plus increased calcium intake did not improve shell quality in FC.

The study concluded that effects of dietary limestone are generally independent of cage system used. Their findings suggest that birds in FC may deposit more calcium in bones than hens in CC. However, this study could not verify weakening of eggshells in FC as being caused by a Ca shortage shunted in favor of higher bone mineralization.

So, what does all this suggest in terms of changing dietary calcium supplementation if considering a change in cage type for laying hen housing? Results do seem to be inconclusive and yet do provide some suggestive indications. Due to greater freedom of movement for birds in a furnished cage environment, greater demand for dietary calcium seems necessary for bone replenishment while maintaining eggshell quality and production. This may manifest itself in elevating dietary calcium concentrations in the feed, but may suggest form of calcium supplementation bears considering as well. Perhaps formulating diets of greater calcium concentrations might be well served by seeking smaller particle sized $CaCO_3$ for the difference in NL vs. HL diets. This would provide a more readily solublized Ca^{++} source to replenish loss of bone while, at the same time, alleviating potential loss of phosphorus being depleted from bone as Ca demand for eggshells and bone formation increases.

Will furnished cages satisfy hen welfare issues being voiced by concerned opponents of layer cages? This issue is far more complex and political than this research is able to address, but this study does provide insight as to what modification may be important as positive solutions are sought.