ilc resources

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Optimum Blend of Fine: Large Particle Size Limestone for Laying Hens

ILC Resources, along with Hy-Line International, cosponsored research conducted by Dr. Sheila Scheideler, poultry scientist at the University of Nebraska, Lincoln. The study's objective was to test recommendation for various fine: large particle blends of calcium carbonate ($CaCO_3$) and dietary calcium and phosphorus effects on egg production, eggshell quality and skeletal integrity in two strains of laying hens widely used in the egg laying industry. These research findings were completed last summer (2003) and were made available to us in December, 2003. Dr. Scheideler will be presenting this data at the Midwest Poultry Federation meetings in St. Paul, MN in March, 2004.

This article will focus on the first aspect to the study, which was to investigate the optimum feeding blend of calcium carbonate particle sizing during the pre- to post- laying periods of egg production.

As Dr. Scheideler pointed out, "Confusion exists among poultry producers about the optimum blend of fine to large particle sized calcium carbonate to use during different stages of egg production. Physical limitation such as number of bins available at the feed mill often limits producers' ability to provide adequate blends of calcium carbonate specific to the needs of the laying hen." Historically, positive benefits affecting eggshell quality and various bone parameters have been shown with feeding larger particle sized limestone (Cheng & Coon, 1990). They showed *in vitro* solubility measurements on large particulate calcium carbonate provided a more accurate basis for feeding recommendations than just particle size alone. Further, larger particle size $CaCO_3$ with corresponding lower *in vitro* solubility values increased Ca retention in the gizzard for layers (Zhang & Coon, 1997), thus providing a source for Ca ionization availability for eggshell formation during peak shell production non-feeding times. Given these foundational studies, plus advancements in layer genetics and current stresses noted for early maturity and egg production in layers, Scheideler's research appropriately investigated optimum particle size combinations of $CaCO_3$ for various strains of birds through a complete laying hen production cycle. Associated with optimizing particle size combinations of $CaCO_3$ is the need for elucidating correct levels of dietary calcium and phosphorus to achieve optimum skeletal integrity and eggshell quality.

For the first trial examining calcium levels and particle size, the research's experimental design accounted for two genetic strains of birds (Hy-Line W-98 and Hy-Line W-36), two levels of dietary calcium, either average (I) or

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high (II), and three calcium carbonate feeding programs (illustrated in the chart below). The trial was divided into five periods of the laying cycle corresponding to weeks of age: *pre-lay, peak (egg production), peak +, post-peak, and end of lay*. The chart graphically depicts this design.

Trial One	**Pre-Lay**	**Peak**	**Peak+**	**Post-Peak**	**End of Lay**
(Wks of Age)	(18-20)	21-40)	(41-50)	(51-60)	(61-70)
Program 1	50:50 Blend of Fine:Large Particle $CaCO_3$ throughout trial (*Fine = Unical-S, Large = Shell & Bone Builder)*				
Program 2	75:25	65:35	50:50	40:60	30:70
Program 3	100 Fine	100 Fine	50:50	50:50	50:50
Calcium I	3.25% Ca	3.65g/d	3.75g/d	3.85g/d	3.95g/d
Calcium II	3.60% Ca	4.10g/d	4.25g/d	4.40g/d	4.55g/d

Results:

Feed Intake (FI) was unaffected by Ca program, Ca level and strain of bird. *Hen Weights* were most consistently affected by bird strain only throughout the trial. *Egg Production* was not affected by Ca level or Ca program.

Egg Weight was most consistently affected by strain of bird (W-98 > W-36), but not by Ca program. Calcium level affected egg weight during peak production (higher Ca, higher egg wts.).

Percent Shell was affected by both Ca program and Ca level. Calcium program affected percent shell during peak period with hens fed 100% fine $CaCO_3$ having less shell compared to those fed 50:50 or 65:35 blends of fine:large particle calcium carbonate. Calcium level affected shell percent during peak period with higher calcium increasing percent shell.

Egg Specific Gravity (measure of density of egg) was affected by both calcium program and calcium level. During peak production, Ca program 3 did not sustain densities compared with programs 1 & 2 (blends of large to fine particle size $CaCO_3$). This correlates with % shell data. Calcium levels consistently increased egg density during the majority of the trial.

Grade A Eggs were affected by a number of interactions between Ca programs and Ca levels at different periods. During post-peak period, when low calcium levels were fed, Ca program 1 produced the best grades, followed by programs 2 & 3. When high calcium levels were fed, Ca program 3 produced the best grades versus programs 1 & 2. It was noted that during the post-peak period there were not large differences in actual blends fed at that time, indicating the effects must have been due to previous period Ca programs. End of Cycle period saw interaction between Ca program and Ca levels. When average Ca level was fed, program 2 had better results. When high Ca levels were fed, programs 1 & 3 supported good grades.

Percent Cracked Eggs were not affected by Ca program, Ca levels, or strain per se, although some significant interactions were observed. When dietary Ca levels were average, Ca programs 1 & 2 produced fewest cracked eggs. When dietary Ca level was high, Ca program 3 had fewer cracks.

Percent Albumen and Yolk were affected little or not at all by dietary Ca program or Ca levels, as one would generally expect. Bird strain effects were marked, with W-98 birds showing greater albumen versus W-36, and just the reverse considering yolk in the egg (W-36 > W-98).

Bone Ash was affected by Ca programs at 35 weeks of age. Program 3 (100% Fine $CaCO_3$ fed up to that point) indicated higher bone ash levels, but this did not correlate with any positive effect ob eggshell quality. On the contrary, % shell and egg densities were reduced in hens on this Ca program during peak lay. The results may be interpreted that hens on Ca program 3 had more bone ash because they were producing less shell and thus, keeping more structural bone rather than mobilizing it.

Summarizing, strain of laying hen consistently affected feed intake, henweight, egg weight and mass, egg quality and egg components, most of whichwere expected. Hy-Line W-98 performed better on high calcium diets versus W-36 birds, which performed well on the low calcium diet.

Depending on what market is targeted (breaker or whole egg) and thus, what type of bird is fed, recommendations can be gleaned from these results to more appropriately tailor a feeding plan to optimize calcium nutrition. From these data, a blend of at least 65% Unical-S (fine granular) calcium carbonate along with 35% Shell & Bone Builder (large particle size) is optimum during peak egg production. After peak egg production, a blend of 50% Shell & Bone Builder and 50% Unical-S would support good eggshell quality. •

Biology of Bone in Laying Hens

A very interesting and technical symposium section recently was published on the issue of avian osteoporosis (*Journal of Poultry Science*, February, 2004). The first reading of these articles was devoted mainly to understanding terminology used. ubsequent readings yielded a rudimentary understanding of the fascinating concepts presented. This is an attempt to share that understanding.

Although similarities exist between human and avian osteoporosis, the avian disease is unique. By its definition, osteoporosis is a progressive decrease in the amount of mineralized structural bone, leading to bone fragility and susceptibility to fracture. The tremendous depletion of calcium from the bones for eggshell production during the egg-laying period, along with other metabolic changes in bone dynamics, puts the laying hen in predictable risk of osteoporosis during each laying cycle.

One of the papers presented in this symposium report was an *Overview of Bone Biology in the Egg-Laying Hen* by C.C. Whitehead from the Roslin Institute in Edinburgh, Scotland. The intent of this article is to summarize and perhaps simplify a few of Whitehead's key points.

Bone has three components: a collagenous fiber component, a ground substance component, and a cellular component. The collagenous fiber component is organic, being comprised of supportive protein material surrounding bone and making up approximately 40% of bone. The ground substance is an inorganic mineral component consisting mostly of calcium and phosphorus. This mineral component gives bone stiffness, rigidity and hardness. The cellular component consists of osteoblasts and osteoclasts. Osteoblasts orm new bone and osteoclasts remove for resorb bone *(re-absorption process)*. Additionally, there are two types of bones: cortical bone band cancellous (spongy or lettuce-like structure) bone. Cortical bone forms the outer shell and cancellous bone forms the inner portion. Both are a part of *structural* bone.

A dramatic change takes place in the bone biology of the hen at the onset of sexual maturity (early laying period). The function of osteoblasts shifts from forming cortical bone to producing a woven bone called medullary bone, the innermost part of bone or *bone marrow*. This latter bone type is a "moving or shifting" source of calcium for shell formation. As osteoblasts change from forming structural bone to forming medullary bone, osteoclasts resorb structural bone, which results in a decline of the hen's structural bone tural bone content. The progressive loss of structural bone during the laying period weakens the skeleton and increases the risk of fracturing bones (characteristic of osteoporosis).

Total bone content may remain constant because of this shift in bone type taking place (from structural bone to medullary bone formation by osteoblasts), but medullary bone is weaker than structural bone. The mechanism behind these changes is driven by estrogen. Circulating estrogen at the onset of maturity stimulates osteoblasts to shift from structural to medullary bone formation, thus weakening the skeletal system, increasing susceptibility to osteoporosis. As the hen gets older and the laying period extended, circulating estrogen declines and osteoblastic structural bone formation resumes.

Increased demand for calcium during shell formation takes place while the egg is in the shell gland. Because this occurs during nighttime hours when supplies of calcium from the diges tive tract typically are low, a high proportion of shell calcium must come from resorbed medullary bone. There is also osteoclastic resorption of bone (for a source of calcium) occurring at exposed structural bone surfaces, thus further driving structural bone loss towards osteoporosis. After the egg is laid, osteoblasts regenerate medullary bone, replacing the osteoclasts that have been resorbing structural bone. Whitehead speculates, "It is probable that ability to mobilize bone, as represented by osteoclast activity, is more important than total medullary bone content in influencing shell quality."

There are other factors, however, that influence bone and shell quality in hens. Nutrition, exercise activity, and genetics play roles in this mechanism as well. Activity and genetics are outside the scope of influence ILC Resources can exert. Nutrition is within the realm of our influence.

Nutritional deficiencies of calcium, phosphorus, and vitamin D have been shown to result in bone loss and are likely to affect severity of osteoporosis. Rennie et al. (1997) demonstrated that dietary treatments involving feeding a large particulate source of calcium (e.g. *Shell & Bone Builder* or *Shell & Bone Builder Blend*) increased the proportions of medullary bone. Fleming et al. (1998) confirmed the practical benefits of feeding particulate calcium sources by observing improved bone strength in older hens. Additionally, this was associated with a lower loss of cancellous bone (structural bone) and a greater accumulation of medullary bone. Their finding that particulate sourced calcium actually increased total amount of bone confirmed that calcium deficiency is not a primary cause of osteoporosis. Another nutritional treatment in the Fleming study was supplementing the diet with vitamin K above normal dietary requirements. They observed a significantly higher cancellous bone (structural bone) early laying period. The advantages of feeding particulate sources of calcium on eggshell quality were confirmed, here and remain consistent with historical studies from the early 1980s (Scott et al. 1982). Not only is eggshell quality enhanced but ths practice is also beneficial for bone

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BSE Issue Revisited

Every trade journal or other agriculture-related publication in the recent months has devoted print space to the issue of "Mad Cow" or BSE. We all have followed the progress from the discovery of BSE in the cow in Washington state last December through much investigation and into new governmental plans for further prevention. While we may agree to varying degrees that the issue has been substantially blown out of reasonable perspective, the fact remains that it is a very serious issue and one for which we will demand proper safeguards.

Quite certainly, there will be more progression of regulatory measures coming forth in our industry to safeguard the public against BSE and other health threats. Compliance with these regulations will not be optional. It behooves us all to take the necessary steps whenthey are presented to insure compliance. It is ultimately easier and safer to keep abreast of regulations when they confront us than it is to be forced into compliance at some future point, after many small procedures are ignored and then become very difficult to assimilate.

On the eve of the discovered BSE infected cow in 2003, our industry passed through one of the first hurdles that was placed to effectively deal with this type of problem. That was registering all food facilities with the FDA as a first measure of compliance toward the Biosecurity Act enacted as a result of September 11, 2001. This is a rather complex system that will become more of a focus as we continue toward effective response to acts of not only terrorism but serious public health threats as well.

What has ILC Resources done to meet compliance and demonstrate leadership 7in this movement? For three to five years we have had an effective "clean-out and truck inspection" policy in place that has worked to address contamination issues from our ingredient supply perspective. This was long before *Facility Registration* and BSE prevention measures were mandated or even considered essential. Vigilance and adherence to these measures will continue to be bedrock to ILC's commitment to our customers and the industry in general.

Feed-grade calcium carbonate is by its very nature free from dangerous contaminations, but we are ready and willing to continue to market contamination-free products and insure that no dangers are inadvertently added before leaving our plants.

Biology of Bone *continued*

quality. Fleming concluded that adding limestone to the diet in the form of larger particles may be associated with "greater availability of calcium throughout the day and night enhancing medullary bone formation, thereby inhibiting structural bone resorption as well as contributing directly to bone strength."

Useful conclusions may be drawn. Foremost, maintaining adequate dietary calcium and associated phosphorus and vitamin D, and probably vitamin K, are fundamentally necessary to help prevent osteoporosis in hens, while at the same time insure quality eggshell formation. Further, the intricate mechanisms surrounding proper bone status and quality eggshell formation appear to be contradictory and quite complicated. Factors influenced by genetic selection and exercise activities may contribute to lessening the negative effects of osteoporosis. More studies may help to quantify these influences more definitively.

For the well-informed poultry scientist that is a part of this *Mineral Writes'* readership, this report may be too simplified. On the other hand, for the layperson among our readership, this information may pose difficulty to fully grasp. Overriding both concerns is our targeted goal of presenting information on the significance of calcium in nutrition, especially as relates to laying hens.

EDITORIAL NOTE:

Can one use the above information and make any speculative statements concerning other species? Caution is necessary when attempting to extrapolate from one species to another. However, it seems reasonable to believe that biological systems do not differ so widely that some information cannot be transferable. Granted, the mechanisms working specifically during the laying period for hens appear to be unique in terms of how calcium is mobilized and the possible alleviation of stress on bones byuse of large particulate sized limestone. Contrasting with laying hen osteoporosis, human post-menopausal estrogen levels suppressing structural bone formation and increasing bone resorption. Thus, conditions do differ between avian and mammalian species. However, thinking of other species, we acknowledge that the dairy cow faces tremendous demand for calcium just prior to and especially following parturition and throughout much of her lactation cycle. In similar fashion, the sow has great need for calcium following farrowing and continuing throughout her brief period of lactation rearing large litters. During this same time the sow typically is quite immobile, thus great stress is additionally exerted on her bone structure. There certainly appear to be differences in hormonal control mechanisms. Yet it is vital to provide adequate nutritional inputs prior to and during these periods of major demand on mobilization of bone elements. Calcium, phosphorus, and vitamins are essential dietary components. Are there correlative interpretations possible from the above treatise relevant to these conditions? Perhaps so, certainly the concepts provide good "food for thought."