MINERAL Writes

THIRD QUARTER 2009

ILC Resources – 85 Years Serving Agriculture

ILC Resources is celebrating its 85th anniversary in 2009. To gain a sense of perspective on those long ago days, we can see that 1924 was a year of significant milestones well acknowledged yet today.

In 1924, Babe Ruth hit 46 home runs and batted .378, Rogers Hornsby batted .424, and Walter "Big Train" Johnson won 23 games pitching for the Washington Senators. A dozen eggs cost 25¢. A spacious seven-room home with garage and land enough to support an orchard cost around $5000. J. Edgar Hoover was appointed head of the FBI. In Russia, Lenin died and Stalin began his iron-handed reign. Macy's in New York held its first Thanksgiving Day Parade. Legendary notables in entertainment such as Marlon Brando, Lee Marvin, Doris Day, Audie Murphy, Don Knotts and *Archie Bunker's* Carroll O'Connor were born in 1924. That year also heralded the founding of today's giant IBM Corporation. Iowa Limestone Company became another landmark.

In the early decades of the last century, the need for better roads was met by using crushed limestone rock, plentiful in many Eastern states. Such sought-after rock was uncovered in the Alden, Iowa, area and a new quarry was developed and run with mostly manual labor. Conflicts and politics finally saw the facilities and general operation at Alden sold to interests in Des Moines, and the new company **Iowa Limestone Company** was born in 1924.

That same year an intuitive farmer came in to the quarry to "fetch home a load of fine ground limestone"

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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
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Eggshell Quality and Bone Quality Dynamics in the Laying Hen As Influenced by Calcium Source, Particle Size and Solubility

Uncovering calcium's role in laying hen nutrition seems to be an ever-widening area of research and experimentation. In an attempt to further understand calcium's part in eggshell formation as well as bone formation in laying hens, let us examine some known dynamics of both.

In a recent Belgian paper dealing with mechanical eggshell behavior, the author stated, "A chicken egg is an already packaged food. An important quality aspect of the packaging material is the mechanical integrity of the shell." The assessment summed up that *eggshell strength* is determined by genetic origin, the age of the laying hen, environmental factors such as feed composition, diseases, climate conditions and management of the bird. All must synchronize successfully for positive results. Dietary supplemental calcium (Ca) source, form and reactive properties make up but one component in this equation, albeit a vital one.

A study at Pennsylvania State University in 2004 described the uniqueness of the laying hen's skeleton, which contains a bone in the marrow cavity (medullary bone) formed just prior to onset of egg laying. Medullary bone is found in the femur (thigh) and the tibia (drumstick) but not the humerus (wing). Medullary bone cycles on a daily basis and contributes 35-40% of the calcium in each egg shell. Following up this assessment, another Penn State study published findings in 2005 exploring medullary bone metabolism and eggshell quality. Seventy percent of egg shell calcium is derived from the diet and 30% from mobilization of medullary bone. Using biomarker technology, researchers found medullary bone synthesis to be active during the time of the egg formation cycle which is the same time of maximum calcium release from medullary bone. The impact of this study suggests that eggshell breakage and bone fragility are two examples of skeletal related problems. Dietary calcium intake must provide adequacy for medullary bone replacement as well as provide Ca for direct absorption and utilization in shell formation. Quantity and timing of Ca delivery are both important factors.

Eggshell quality and sound bones are critical concerns to the layer hen business. The concept of properly maintaining eggshell quality by feeding large particle calcium carbonate ($CaCO_3$) is well recognized and documented. Eggshell formation is enhanced not simply by large particle Ca deposited in the gizzard, but must also account for availability of ionized Ca^{++} to the hen based on the corresponding *acid solubility* characteristics of the $CaCO_3$ source being fed. A brief review of acid solubility and why its consideration is important may be of value here.

To begin with, calcium carbonate reacts with hydrochloric acid (HCl) in the stomach to release ionized Ca^{++} for absorption and utilization for bone formation and eggshell formation. How reactive a given particle size gradation $CaCO_3$ product is can be measured by *in vitro* solubility analysis. To simulate *in vivo* digestion, lab testing calls for dissolving samples of $CaCO_3$ in HCl and measuring disappearance rates among samples in a given time. How rapid and complete this process proceeds is inherently influenced not only by particle size (relating to surface area exposure to acid) but also by compositional differences of rock source (hardness and porosity characteristics). To understand how lab measured solubility results correlate to actual digestion of large particle $CaCO_3$ in laying hens, an inverse relationship exists between *in vitro* and *in vivo* solubilities of large particle $CaCO_3$. Large particles (~ 1000 microns and greater) deposit in the gizzard (Fig.1). There, they are constantly bathed in the acidic digestive juices (HCl) of the stomach. Large particulate $CaCO_3$ releases Ca^{++} ions slowly, thus making Ca available for absorption in a metered fashion over periods of time when the hen is not feeding, typically nighttime hours when greater eggshell formation is taking place. Thus, large particles dissolve slowly, and Ca^{++} is available on a timelier basis for eggshell formation and bone structuring (Fig.2).

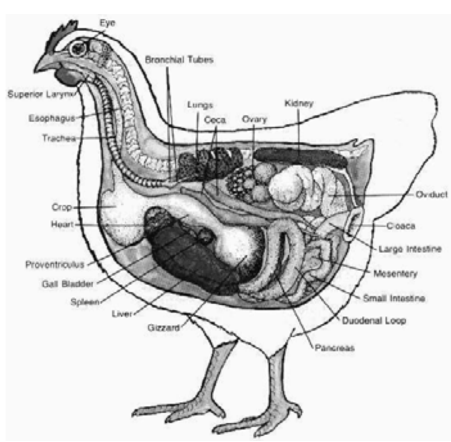

Fig. 1

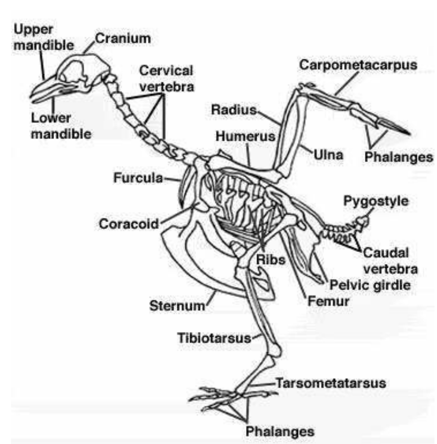

Fig. 2

Small granular to ground $CaCO_3$ does not deposit in the gizzard but solublizes fairly rapidly in the stomach, and Ca^{++} passes through with other digesta en-route for absorption in the small intestine.

Sources of $CaCO_3$ products coming from different calcitic limestone deposit locations have different solubility rates even if similar in particle size profile. Thus, both particle size and acid solubility rates are important factors to consider in meeting dietary needs in calcium (Ca) nutrition.

Concurrent with direct egg shell formation, Ca plays a part in bone quality of the laying hen. Aside from mobilizing Ca from medullary bone for shell formation, poor bone quality in laying hens can lead to many problems, which include broken or weak bones, osteoporosis, economic losses, and difficulties at processing plants that can result in bone fragments in meat products. Thus, for both critical concerns, optimizing supplemental dietary Ca sources becomes paramount in successful egg production.

Two recent studies shed additional light on these issues. One study came out of Canada, the other from England. The first collaborative work was from Nova Scotia Agriculture College (NSAC) in Truro with researchers also from the Atlantic Poultry Research Institute in Truro and the University of Alberta at Edmonton, Canada. D.M. Anderson from NSAC authored the paper titled *"The effect of calcium source and particle size on the production performance and bone quality of laying hens,"* which was reported in the February 2009 Journal of Poultry Science. The second study was conducted at the University of Bristol in Bristol, England, and published in the April 2009 edition of the International Journal of Poultry Science. Authored by K.C. Koutoulis, this report was titled *"Effect of Different Calcium Sources and Calcium Intake on Shell Quality and Bone Characteristics of Laying Hens at Sexual Maturity and End of Lay."* This collaborative study included researchers from Bristol, England (University of England); Karditsa, Greece (University of Thessaly); and Pietermartinzburg, South Africa (University of KwaZulu-Natal).

These studies provide useful overlapping discoveries. Our attempt will be to draw key points from each as we seek greater understanding of the dynamics of Ca nutrition in the laying hen. For the sake of identification, the first study will be designated as the *Canadian* study and the second as the *English* study.

The Canadian study examined the effects of three different Ca sources and the effect of large versus small particle size on laying hen production performance, eggshell quality, and bone quality. Two particle size combinations were used as treatments from each Ca source. Although Ca analysis on treatment sources supported their true definitions as *calcium carbonate*, the Canadian researchers used the term "limestone" instead. One particle size level was of ground limestone which consisted of particle sizes from 425 microns and below. *For reference, 1000 microns equals 1 millimeter (mm).* The other particle size level was large particle limestone which ranged from 500 microns to greater than 4000 microns. DeKalb laying hens (19 wks old) were assigned to treatments of 100% ground or combination of 33% large particle -67% ground of each limestone source. The control treatment was oyster shell along with a ground commercial limestone (GCL) product. The three additional treatments came from each of three different mined sources of limestone. Diets were balanced to 1994 NRC nutrient requirements, and only Ca sources differed in the diets. Five feeding phases corresponded to timing of dietary changes and levels of egg production (Table 1).

Table 1	Feeding Phases -- Dietary Changes				
Dietary Calculations:	Phase 1 19-26 weeks old	Phase 2 27-46 weeks old	Phase 3 47-50 weeks old	Phase 4 51-70 weeks old	Phase 5 71-74 weeks old
% Ca	4.00	3.80	3.67	3.73	3.82
	(gms/hen/day)				
Feed Intake	90	100	110	110	110
Calcium per day	3.6	3.8	4.0	4.1	4.2

Table 2 Ca Source Data

Ca Source	Particle Size		% Acid Solubility	% Ca
	Category	Average Microns		
Oyster Shell	large	2958	53.4	37.51
Commercial Grd Limestone (CGL)	ground	< 425	66.6	37.95
Limestone Source A (white)	large	2147	41.4	38.65
	ground	< 425	67.3	
Limestone Source B (brown)	large	2002	45.2	38.03
	ground	< 425	66.6	
Limestone Source C (gray)	large	2060	43.5	38.10
	ground	< 425	64.4	

Particle size and solubility data is presented in Table 2.

Both egg production and percentage of unmarketable eggs were unaffected by particle size of Ca source. The results of this study were in contrast to many other studies, which reported a positive effect of particulate Ca sources on eggshell quality. The current study replaced only a third of the ground limestone with either oyster shell or particulate limestone, whereas others have reported replacement levels from half to 100%. Based on impact of gizzard deposition of large particulate Ca sources as well as respective lower solubility values, this study acknowledged that their trial differed from previous research based on its lower proportionate amount of large particle Ca added to the diet. Bone characteristics were improved by the addition of large particle Ca source. The hens which received the mixed particle size treatments had increased total and trabecular bone mineral density (BMD), cortical area, total and cortical bone mineral concentration (BMC), bone weight, and breaking strength over the 100% ground Ca source treatment groups. All mixed treatments contained 33% large particulate Ca sources of similar particle size and acid solubilities. The Canadian study did state, "Although both particle size treatments yielded similar egg production and eggshell quality, the hens in the mixed particle size treatment groups were apparently able to do this with less support from structural bone reserves (i.e., cortical bone)." This perhaps helps explain benefits recorded by other studies regarding improved eggshell quality with even higher inclusions of large particle $CaCO_3$. This study concluded that "Increased bone quality in the laying hen may help reduce the incidence of osteoporosis, cage layer fatigue, and other bone problems in laying hens caused by high Ca demands for egg production."

The English study examined the effects different Ca sources and Ca intake levels had on eggshell quality and bone characteristics of laying hens at sexual maturity through end of lay. These researchers acknowledged a scarcity of information on bone characteristics related to feeding calcium in a particular form throughout the laying period. Thus, "their experiment was conducted to test the hypotheses that (a) an improvement on bone properties, physical or mechanical, could be achieved by supplying the birds with a different source of calcium during the rearing period, and (b) shell quality and bone characteristics are closely correlated with higher calcium intake and its provision in a particular form." Prior to reaching sexual maturity, pullets were offered diets including either supplemental "limestone flour" (< 400 microns) or "limestone granules" (> 400 microns). Grower diet was 1.2% Ca, and layer diet was 4.19% Ca. The birds were allowed free choice access to additional limestone according to treatment source and form. Egg production, mean egg weight and mean shell weight were recorded throughout the laying cycle (25 weeks through 70 weeks). Additional calcium offered free choice had no impact upon age at first lay, egg weight, shell weight or shell thickness. Birds offered supplemental calcium increased their tibia breaking strength between sexual maturity and end of lay. Calcium supplementation did not affect egg production, egg weight or shell weight, but birds offered granular limestone had higher shell thickness.

Regarding bone characteristics, "bone stiffness is the internal bending resistance of the molecular structure of the bone to external rotational forces and may be an indicator of the degree of mineralization." As bone mineralization increases, so bending moment increases. Medullary bone, which is formed during the last two weeks prior to first egg, is not believed to have any structural function. However, the English study observed that birds given supplementary calcium had higher bone breaking strength, which may have been a result of better medullary bone formation. This study reported, "Birds supplemented with limestone granules had stronger and stiffer bones than controls, probably due to slow, constant and uniform release of extra calcium which not only benefited egg quality, but might well have contributed to increased bone mineralization and medullary bone formation." The author concluded that "supplementation of calcium from various sources during the pre-laying period might not have increased bone quality to the maximum degree, but there is strong evidence that, in the long term, it helps to increase egg quality, mechanical properties of the bone and, as a consequence, to reduce the risk of broken bones at the end of laying period."

What can be drawn from these studies? Egg shell quality and bone structural integrity go hand in hand. A high percentage of shell formation is derived from dietary calcium sources in appropriate timing of Ca^{++} availability as influenced by particle size and reactive solubility in stomach acid. Equally important, however, is the contribution of calcium being mobilized from the medullary bone. Both metabolic pathways must function properly to maintain egg shell strength as well as bone strength and integrity. Slower released Ca^{++} from large particulate $CaCO_3$ contributes directly to egg shell formation while at the same time replenishes Ca for medullary bone formation. One would speculate, then, that calcium released from all large particulate $CaCO_3$ would be what is needed. However, to balance out Ca availability and to carry on physiological functions in the bird, both small particle and large particulate calcium sources are needed. Quickly solublized Ca^{++} from small particle Ca sources is necessary along with slower released Ca^{++} from large particulate Ca sources to allow steady availability of Ca to the laying hen. Historical findings at Nebraska in 2004 demonstrated benefits of blending large and small particle $CaCO_3$ to the laying hen. As the hen ages, proportionately more Ca needs to come from slower dissolved large particulate $CaCO_3$ to maintain egg shell quality. One cannot separate the two functions of egg shell formation and bone formation. A blend of both large and small particle calcium accounting for varying dissolution rates during digestion will allow necessary Ca^{++} available to meet the hen's needs for eggs and bone. Previous work by Zhang & Coon at Minnesota provided guidelines recommending that large particle $CaCO_3$ should run at a minimal 1000 microns* average particle size with corresponding acid solubility range of 30-50% (based on Coon 1997 research). To achieve such, sources from varying locations may need different blending of particle sizes to achieve desired results.

As an example, a large particulate product from one ILC Resources plant may be more acid soluble than another location's similar particle size product. Consequently, to take into account adequate particle size as well as solubility values, one must use different blends of products from different locations to achieve comparable dietary Ca source supplementation.

To illustrate this point, a *half-half blend* of an extra-coarse particulate product with a small granular product from one plant yielded a calculated value of 1750 microns average particle size and 43.6% acid solubility. If the same blend is used from another plant location, the average particle size calculates 1734 microns (pretty close!), but the acid solubility is only 37.8% (difference = ~6%). A closer mixture from the second plant would be 25% extra coarse/coarse particulate blended product, 50% coarse particulate product and 25% small granular product. The average blended particle size calculates to 1689 microns and acid solubility value of 38.4% (difference narrowed to ~5%), but particle size was only compromised by 45 microns. Other comparisons and blends can be made as well. In each scenario, we must keep in mind to balance the blend to maintain at least 1500 microns* average particle among large particle material and a range of acid solubility between 30-50%.

There remains need for additional research and testing to further elucidate these dynamics among different $CaCO_3$ sources, but the tools exist already to bring us closer to equalizing product choices to optimize performance in both eggshell formation and sound bone structure. If interested, upon inquiry we would welcome sharing more detailed data comparisons of products and blends between different locations.

Recalling earlier points of assessed impact of bone and shell quality, we perhaps should conclude by reiterating these dynamics are "determined by genetic origin, the age of the laying hen, environmental factors such as feed composition, diseases, climate conditions and management of the bird. All must synchronize successfully for positive results. Dietary supplemental Ca source, form and reactive properties make up but one component in this equation albeit a vital one." Each of these factors needs to be effectively managed to minimize negative impact while optimizing successful performance. It is a challenge to accomplish all of them but with a T.E.A.M. *("together, everyone accomplishes more")* effort, it is possible. ILC Resources pledges its part to this team effort.

* In 2006, ILC Resources adopted *laser diffraction* technology in measuring particle size. On the average, products tested by sieve analysis screening have correlated to approximately 45-50% greater over all average particle size by *laser diffraction*. Refer to first quarter 2008 edition of *Mineral Writes* for more detail. Thus, targeting minimum 1000 microns by sieve analysis equates to approximately 1500 microns by *laser diffraction*.

(Continued from front page1)
to add to the grain and silage he was feeding to his livestock. Iowa Limestone's focus on supplying the feed industry began that day and has held true to this day. High calcitic limestone contains very pure *calcium carbonate* (95% or greater), which subsequently became well recognized as the standard for calcium ingredient supplementation in animal feed. Animal nutritionists began to discover its feeding value. More conventional uses of limestone including road building stone and cement mixtures yielded to include calcium carbonate's importance in meeting primary requirements in livestock nutrition. That became the direction of commitment Iowa Limestone Company foresaw as its primary business focus.

Initially, the "fines" were a waste product for disposal. As farmer interest and demand grew, Iowa Limestone Company invested in grinding machinery to produce specifically for that demand. By the 1960s, screening for specific particle size gradations was introduced to meet the mounting needs rising from better understanding of feeding livestock and poultry supplemental calcium. Iowa Limestone Company devoted significant attention to modernizing its plants with the kind of grinding and separating equipment to make calcium carbonate products available in forms feed manufacturers and others found best for improving performance in animals and poultry.

In the mid 1980s Iowa Limestone Company expanded its business by purchasing facility operations in Weeping Water, Nebraska. New market territories opened up as a result. Continuous plant renovations and updated machinery answered mounting needs. However, over ensuing years, even greater demand for ILC's precise products was met in part through affiliations with other operational sources of calcium carbonate in Nebraska, Iowa and Minnesota. Today, our company's network supplies reliable, consistent, high-grade calcium carbonate to agribusinesses throughout the Midwestern states, Canada and beyond.

Iowa Limestone Company's name evolved into **ILC Resources** in 2003. Recognizing a broader base of marketing than just *limestone* suggested a more encompassing name. We long since realized that our business extended beyond the state of Iowa alone. Limestone is not the sole product we market. Besides, more accurately it is calcium carbonate, not generically *limestone*. ILC Resources is a valuable supplier to the industries we serve. Agriculture remains our primary focus. Calcium carbonate continues to be the primary mineral ingredient we supply, but we do furnish additional products and services. Phosphorus, potassium and bentonite clay mineral ingredients compliment our calcium carbonate products. Transportation of products to meet timely, efficient, cost-effective delivery is but one example of our services. All services contribute to customer expectations. It is not happenstance, however, that the initials ILC were retained as a reminder of our heritage and dedication.

Perseverance, commitment and human energies combined years ago to form the basis of Iowa Limestone Company's early success. That same formula for success remains steadfast today. None of the sustained success would have been, or would continue to be, possible without the loyalty of satisfied customers. Our 85th Anniversary is a celebration of serving animal agriculture. Looking around our industry, we see that change has been explosive and widespread. Many individual businesses have only short-term histories. Even the partial list from 1924 attests to fleeting longevity. Not much from 1924 remains viable today, but ILC Resources certainly does.