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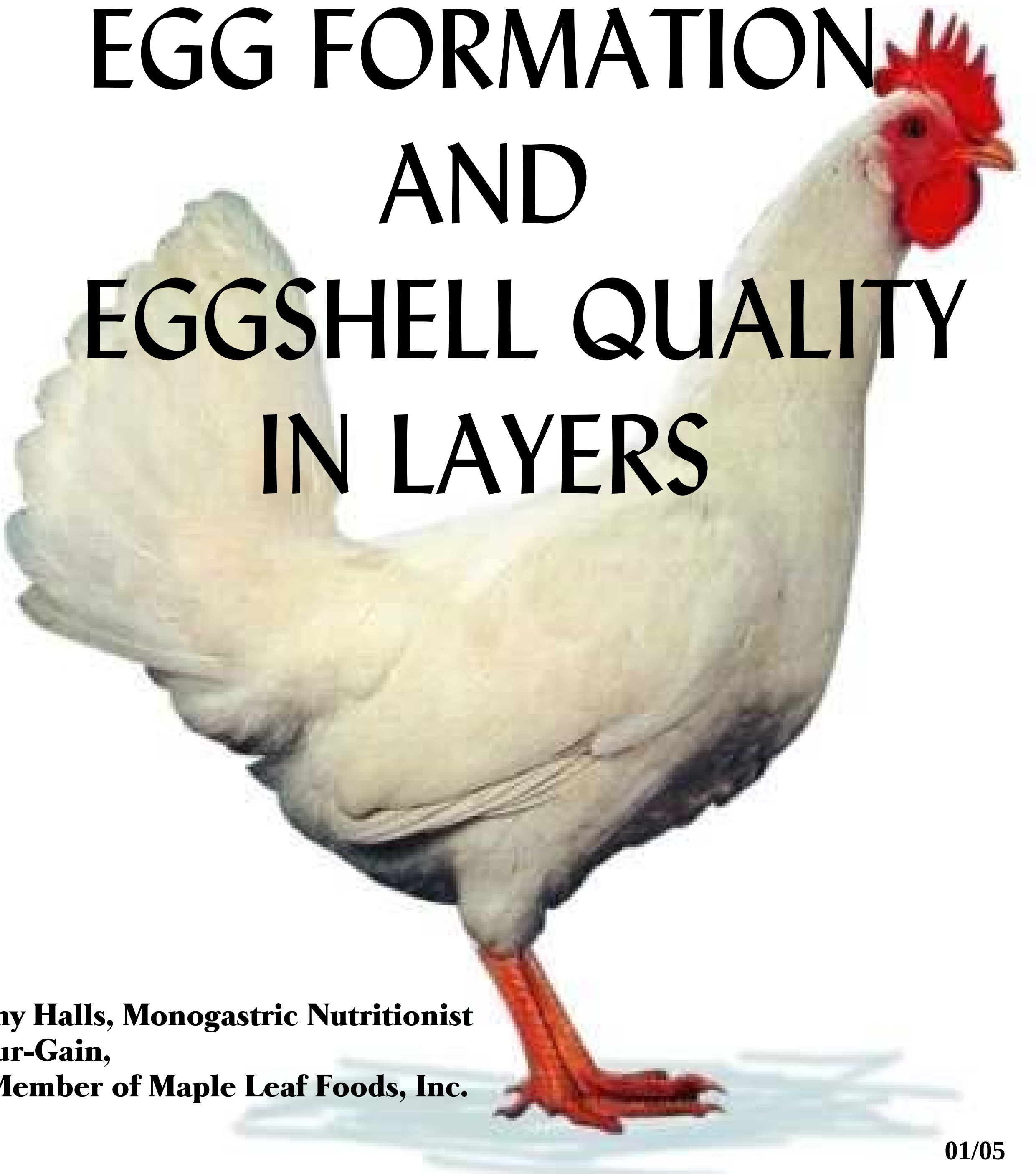
EGG FORMATION AND EGGSHELL QUALITY IN LAYERS



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EGG FORMATION AND EGGSHELL QUALITY IN LAYERS

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Eggshell quality is of major importance to the egg industry. This Nutrifax briefly reviews the formation of the hen's egg, mineral importance and eggshell quality in laying hens. Eggshell quality has a major economical impact on commercial egg production. Broken and cracked eggs represent an economic loss to egg producers. 6-8% of all eggs produced commercially are unusable because of shell quality issues. Numerous factors involved in eggshell quality include nutrition, age, stress and disease. Understanding the factors that can affect shell quality is vital for the production of eggs with the highest quality possible.

EGG FORMATION

The hen's reproductive system is a very complex system that can produce an egg in 24 hours. An egg consists of the yolk (30 – 33%), albumen (~ 60%), and shell (9 – 12%) (Figure 1).

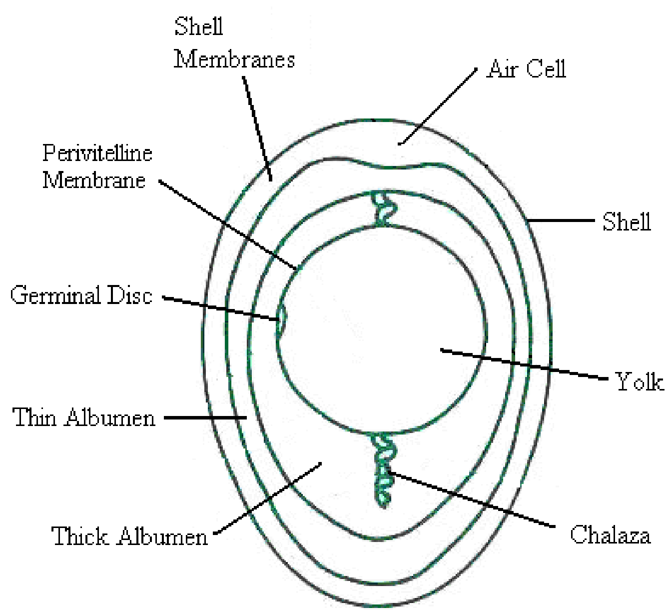


Figure 1. Formation of the hen's egg.

The formation of an egg occurs in the ovary and oviduct. Although two sets of ovaries and oviducts are present during embryonic development, only the left set fully develop in chickens. The mature ovary will have several follicles in different development stages at any one time (Figure 2). The largest follicle is the one to be ovulated to produce an egg. The ovary will normally produce one mature yolk on a 24h light/dark cycle. The follicular membrane ruptures and releases the follicle at the time of ovulation. This usually occurs about 30 minutes after the hen has laid an egg.

After ovulation, the yolk is captured by the infundibulum. The formation of the chalazae and perivitelline membrane occurs in this section of the oviduct. It is believed that an enzyme secreted in the infundibulum is activated once the egg reaches the magnum, the second section of the oviduct. The activated enzyme, in conjunction with the rotation of the egg as it moves down the oviduct, causes the albumen to separate and twist at the poles, forming the chalazae. It will take approximately 15 minutes for the yolk to pass through the infundibulum. Fertilization occurs in this region of the oviduct in breeding birds.

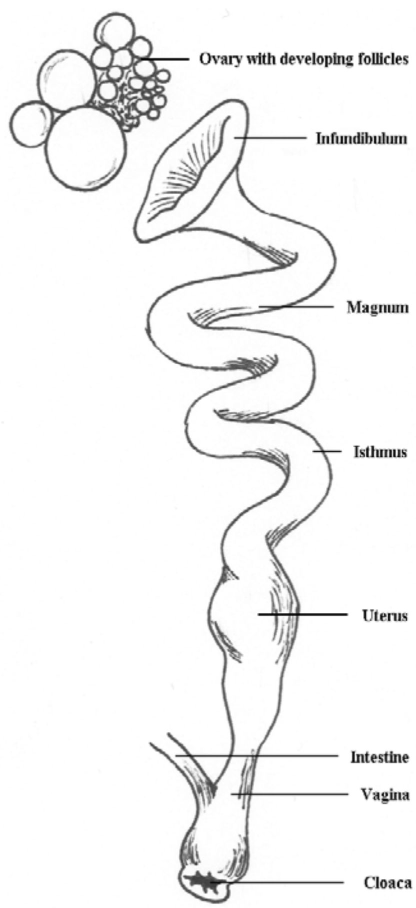


Figure 2. Reproductive system of the hen.

The albumen, or egg white protein, is deposited when the yolk is in the magnum. The magnum is the longest part of the oviduct and the yolk will take 2-3 hours to pass through the magnum. Although to the naked eye albumen appears homogenous, it actually is fibrous and multilayered. The albumen has several functions, which include a nutritional source for a developing embryo, a cushion to protect the yolk against mechanical injury, a bactericide to prevent infection and as a template for the deposition of the shell membranes. Next, the developing egg passes into the isthmus, where the inner and outer shell membranes are formed. This process takes approximately 1½ hours.

The egg then enters the shell gland or uterus, where it will spend 18 to 21 hours. During that time the albumen takes up electrolytes and water through a process called "plumping". The shell, which consists of roughly 95% calcium carbonate and 5% organic material, is also formed in the shell gland. The hen's calcium requirements are highest at this stage of egg formation. Once the shell is completely formed, a protective coating called the cuticle is laid down over the shell. The laying of the egg, or oviposition, is induced by hormonal contractions of the uterus. The egg passes through the vagina and exits via the cloaca.

FACTORS AFFECTING EGGSHELL QUALITY

Calcium

Calcium availability is a major component that can affect eggshell quality in layers. Both an excess and a deficiency of calcium will negatively affect shell quality. Excess calcium will decrease phosphorus availability and reduce feed intake, which will affect shell quality, as well as egg production. Calcium deficiency will also affect shell quality and tends to deplete the calcium content of the bone, which can lead to brittle bones and fractures or Cage Layer Fatigue.

Calcium requirements for the laying hen are relatively low, except when the eggshell is forming within the shell gland. The greatest rate of shell formation occurs during the dark phase or at night when the birds are not eating (Figure 3).

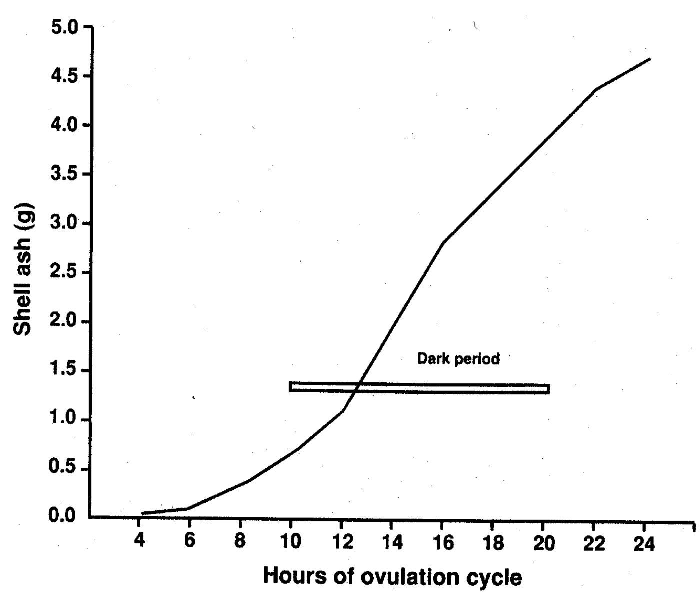
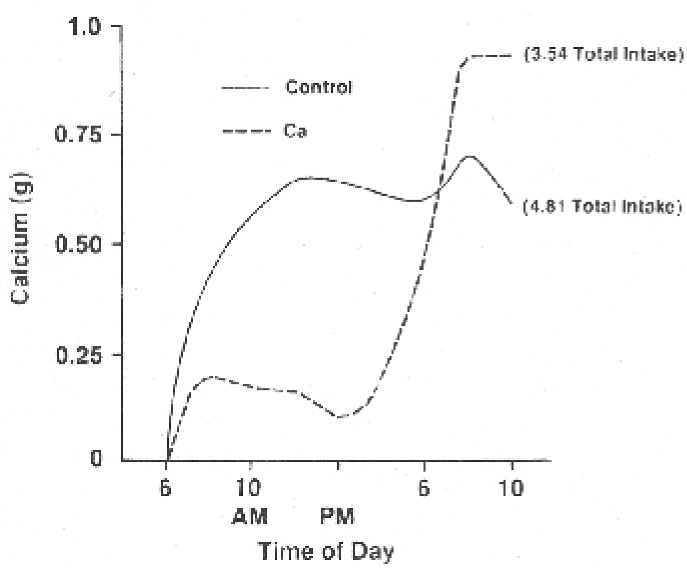


Figure 3. Shell mineral deposition over a 24 h ovulation cycle (Leeson, 1997).

There is basically no shell deposition in the first 6 hours of the 24h laying cycle of the hen. During this time the albumen and shell membranes are being secreted. The majority of calcium deposition occurs between 12 – 18 h, and is followed by a slower calcium deposition in the last 6 hours of the laying cycle. About 2.5 - 3g of calcium are used in shell formation, regardless of egg size.

The hen will obtain the required calcium from the diet via the intestine and also from medullary bone reserves. Medullary bone is found in sexually mature, egg producing birds. It is the primary bone calcium reserve for eggshell formation. Medullary bone calcium can be deposited and released in response to changes in calcium supply and demand during eggshell formation. Intestinal calcium absorption reaches over 70% when the shell gland is actively forming the shell. An average of 4g of calcium is required in the diet to maintain good shell quality since only 50 - 60% of dietary calcium is actually used in shell formation. The calcium bone reserves are replenished during the time when the shell gland is in the inactive state.

Research indicates that shell quality improves if hens are fed part of their dietary calcium as large particle limestone (shellrock) or oyster shell. There is a beneficial response to feeding large particle calcium carbonate as a substitute for part of the fine particle calcium carbonate in the diet (Figure 4). The control diet (Control) with a constant level of calcium did not allow the hen a choice as to what time of the day calcium was consumed. However, hens offered diets varying in calcium content (Ca) were able to select calcium at any time. These hens consumed the majority of their calcium intake during the afternoon. During this time of day, the egg is usually in the shell gland during the 24h laying cycle, and calcium requirement is usually higher at this time. In addition, the larger particles are retained within the gut of the hen and provide a longer acting source of calcium thus reducing the need for excess calcium resorption from the medullary bones. This indicates that providing hens with free choice calcium in the form of shellrock or oyster shell during the afternoons provides the calcium for the shell deposition period. There is no difference in the effectiveness of large particle oyster shell or large particle



limestone.

Figure 4. Calcium intake during egg formation (Chah, 1972).

It is not recommended to feed large amounts of shellrock or oyster shell on a continuous basis <u>in addition to the dietary calcium supply in the complete feed</u>. Hens offered high levels of calcium *ad libitum* may produce shells with chalky deposits and rough ends, as well as soft-shelled eggs.

Phosphorus

Phosphorus is also a key component in eggshell formation. Eggshells contain very little phosphorus, but this mineral interacts with calcium during bone formation. Excess phosphorus in the diet will increase the phosphorus levels in the blood and inhibit the mobilization of calcium from the bone or digestive system. Excess phosphorus and calcium-deficient diets have been linked to Cage Layer Fatigue. Low phosphorus levels can cause the production of soft-shelled eggs.

When adding extra calcium to layer diets the calcium to phosphorus ratio should be taken into consideration. Balanced calcium to phosphorus ratios will enable the layer hen to produce quality eggshells as well as deposit calcium in her medullary bone reserves. Shur-Gain's layer rations contain a balanced ratio of calcium and phosphorus for good eggshell quality. Recommendations for the addition of calcium and phosphorus to balanced layer rations are given below.

Add 0.5 kg Dicalcium Phosphate (Dical) for every 5 kg Oyster Shell/Shellrock added over 10 kg Oyster Shell/Shellrock per tonne of complete feed. This will balance the calcium to phosphorus ratio in the diet.

Table 1. Guideline for top dressing layer rations with calcium and phosphorus sources.

Topdress Ingredients	
Oyster Shell / Shellrock (kg/tonne complete feed)	**Dicalcium Phosphate (kg/tonne complete feed)**
10	--
15	0.5
20	1.0
25	1.5

Vitamin D_3

Vitamin D_3 is essential for calcium and phosphorus absorption from the intestine during shell formation. Although calcium can be passively absorbed from the gut, vitamin D_3 enables the bird to absorb sufficient quantities of calcium to maintain eggshell formation and normal medullary bone reserves. Deficiencies of vitamin D_3 can result in a significant loss in shell weight. Extremely high dietary levels of vitamin D_3 may cause pimpling of the shells.

All Shur-Gain layer rations contain sufficient vitamin D_3 levels for proper calcium absorption. However, the addition of vitamin D_3 in the drinking water can also help shell quality, particularly in older flocks. If shell quality is declining, adding 20-30 ml of **SOLU-VIT D_3™** or **HYDRO-VIT D_3™** per 2000 L of drinking water 1-2 times (non-consecutive days) a week is sufficient in improving shell quality, along with other measures previously mentioned.

Age

Eggshell quality tends to decline with the age of the layer flock. Shell quality is reduced at this time due to two main factors. Egg size and weight increases with increasing hen age and is generally not accompanied by a relative increase in shell weight, which leads to a decrease in the shell weight to egg weight ratio. Hence, larger eggs will have a thinner shell. Secondly, the ability to mobilize calcium from bone declines as the hen ages, and the hen is less able to provide the needed calcium from her bone reserves for eggshell formation. Providing extra dietary calcium in the form of shellrock or oyster shell to older layer flocks during the afternoon can further enhance the shell quality of larger eggs.

Stress

Several factors that induce stress in a layer flock can adversely affect shell quality. Stress induced by relocation, changes in routine or sudden disturbances can increase the incidence of deformed eggshells, such as body-checked eggs. Body-checks are eggs with shells that have been cracked during shell calcification and have been repaired with a layer of calcium deposited over the crack prior to oviposition. Stress can also cause hens to retain their eggs and delay oviposition, and can result in a higher number of white-banded and slab-sided eggs. White-banded eggs are those that are retained in the shell gland longer then the normal oviposition time and slab-sided eggs are those that enter the shell gland when the previous egg is still present.

High temperatures can cause heat stress in layers and may result in smaller eggs and reduced shell quality. Heat stress reduces feed intake and limits the amount of absorbed calcium for eggshell formation. Hens exposed to temperatures over 85-90^{o}F have increased incidences of thin, porous or shell-less eggs. Panting can also upset the acid:base balance of the blood leading to poor shell quality. Feeding practices during hot weather should focus on feeding layers adequate levels of essential nutrients. It should also be noted that layers tend to eat most during the cooler times of the day. The availability of cool drinking water can also lessen the affect of heat stress in layers.

Disease

Generally any disease that affects the health of a laying hen may indirectly reduce eggshell quality. Newcastle disease and infectious bronchitis may cause rough or abnormal shell texture. In addition to production drops, egg drop syndrome and avian influenza may also cause deformities such as thin or soft-shelled eggs.

OTHER FACTORS

If the addition of extra calcium, phosphorus and vitamin D3 does not improve shell quality, contact your Poultry Territory Manager or poultry specialist who will work with Shur-Gain Nutritionists to develope a custom ration that will further aid in shell quality.

As mentioned above, many factors affect the quality of an eggshell. Awareness of these issues allows egg producers to closely monitor eggs for optimal shell quality. Good management practices with respect to hen health, nutrition, egg production and egg handling will contribute to the quality of an eggshell.