

CALCIUM AND PHOSPHORUS A NECESSARY BALANCE IN BROILER DIETS

Vitor Hugo, Nutritionist, World Technical Services-Cobb Vantress

nutrition



INTRODUCTION



Through **genetic improvement**, a broiler's **growth rate** and target body weight has **accelerated** over the years, which requires a **regular review** of nutritional formulations.



Moreover, research is providing more information regarding the complex **interactions of feed components at the macro and molecular level** in the gastrointestinal tract.

When formulating feed, considering the synergistic and antagonistic interactions of ingredients can optimize formulations to promote performance and support animal health and welfare.

Five of the minerals:

- Ca Calcium
- P Phosphorus
- Na Sodium
- Cl Chloride and
- K Potassium

That are supplemented in broiler diets are important **regulators of homeostasis and involved in cell signaling.**



Calcium and phosphorus are also important in skeletal development, strength, and maintenance



Ca and P are largely located in the bones and two of the most abundant minerals in the body. **Consequences of imbalanced ratios or deficiencies of Ca or P in broiler diets include reduced growth performance, increased feed efficiency, poor bone mineralization, or, in severe cases, death.**

Amino acid digestibility and P availability can also decrease when an excess of Ca is present in the diet.

FUNCTIONS OF Ca AND P

In the body, 99% of Ca and 80% of P is stored in the bones as hydroxyapatite. The remaining 1% is in cell organelles and extracellular fluid.

Calcium functions outside the bones

- ✓ Required for **muscle contraction**
- ✓ Regulating **heartbeat**
- ✓ **Nerve conduction**
- ✓ **Blood coagulation**
- ✓ Regulates **cellular osmotic pressure**

Organic Phosphorus bound to proteins and blood cells encompasses 70 % of phosphorus. Inorganic Phosphorus (Pi) can be ionized (Phosphates), complexed with cations (Na+, Ca++, Mg++), or bound to proteins.

Phosphorus / Phosphate functions outside the bones

- ✓ **Nucleic acid (DNA and RNA) backbones**
- ✓ **Cell signaling**
- ✓ **Gene transcription**
- ✓ **Energy compounds (ATP) founded on P**
- ✓ **Enzyme activity**
- ✓ **Proteins, carbohydrates, fat metabolism**



EMBRYONIC DEVELOPMENT

During embryo development, P is mainly stored in the yolk while Ca is stored in the yolk and eggshell.

It was reported that P concentrations in the yolk at Day 0 are reduced by half at Day 17. Conversely, Ca concentrations in the yolk nearly double over the same time.

The increase in Ca occurs because it is absorbed from the eggshell into the embryonic circulatory system and then deposited in the yolk (Figure 1). However, P is limited to the amount that was deposited in the yolk from the hen.

The embryo uses the Ca and P stores for bone construction during incubation. At hatch, only yolk sac stores of these minerals are available. In addition to bone mineralization, Ca and P are also needed for other cellular and metabolic processes.

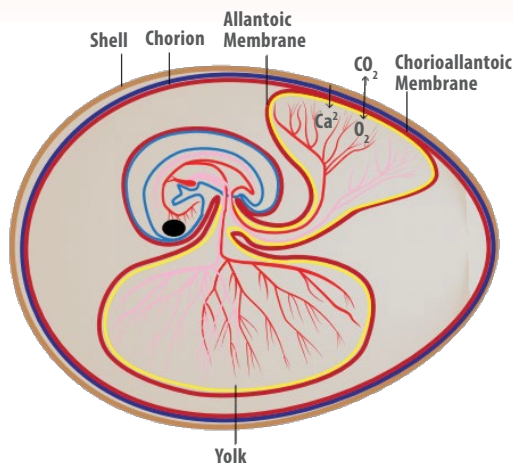
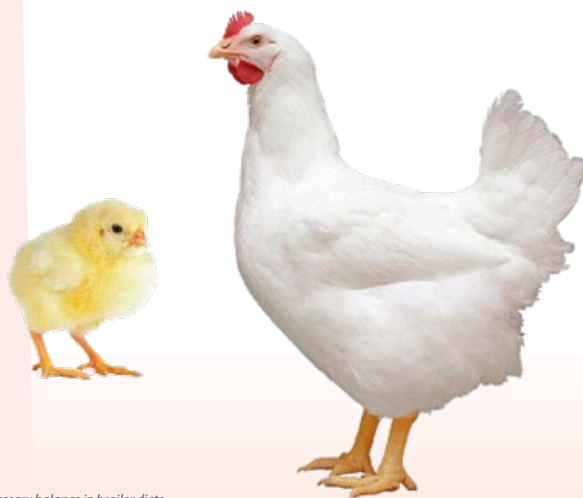


Figure 1. The allantoic membrane fuses with the chorion to form the chorioallantoic membrane. This highly vascular membrane develops around day 5 to 6 and adheres to the inner shell membrane. The chorioallantoic membrane functions in gas exchange and, at about day 10, begins absorbing and actively transporting calcium from the shell to the embryonic vascular system. The calcium is then deposited and stored in the yolk. This process continues until day 17.

GROWTH

During incubation, the long skeletal bones rapidly grow in width and length. (The tibia more than doubles in length from day 15 to 20!). Because the embryonic growth rate exceeds the mineralization process, the bones are largely spongy at hatch.





After hatch, the **leg bones lengthen and expand radially very rapidly**. The cortex (compact outer bone) becomes porous because the deposition of collagen outpaces the rate of mineralization. However, the **cortex thickness and mineralization reach a maximum at about 4 to 5 weeks of age**.

Bones continue to grow throughout the life of the broiler and require a steady supply of dietary Ca and P. However, the rate of growth and requirement of Ca and P at different stages should be considered.

For good skeletal foundation and development, nutritionists agree that Ca and P should be the highest in pre-starter and starter feeds.



Bone modeling is the **physiological process of bone growth in shape and size**. Bone modeling is predominant in developing and young birds. Bones grow both longitudinally and radially. Bone modeling occurs in **response to mechanical or physiological impacts, such as weight gain**.

Bone remodeling occurs throughout life and is the **replacement or renewal of old bone** (Figure 2). The process is necessary so that bones can maintain strength and repair microfractures.

Moreover, remodeling is required to release Ca and P stores when blood levels are low and these minerals are needed for other cellular functions.

BONE GROWTH : MODELING AND REMODELING

Both modeling and remodeling require Ca and P to mineralize and harden the bones.

Without sufficient levels of Ca and P, bones will not harden!

Chronic deficiency of P and / or Ca causes impaired skeletal mineralization, a common characteristic of Rickets.

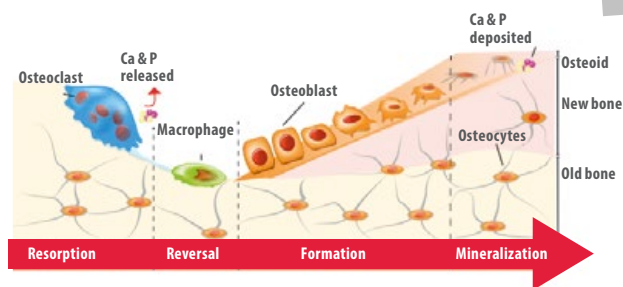


Figure 2. In bone remodeling, osteoclasts absorb bone tissue and Ca and P are released. Macrophages support the osteoblast formation of bone and engulf any osteoblasts that die and do not become embedded in the new bone. To create new bone, osteoblasts first secrete osteoid, a collagen matrix. Some osteoblasts will become embedded in the matrix. The osteoid matrix is then calcified by the addition of Ca and P.

ABSORPTION, SECRETION, AND REGULATION

Calcium and phosphate levels in the body are controlled by balancing intestinal absorption with renal excretion. Both are absorbed in the intestinal tract. However, availability is also regulated by reabsorption and excretion in the kidneys.



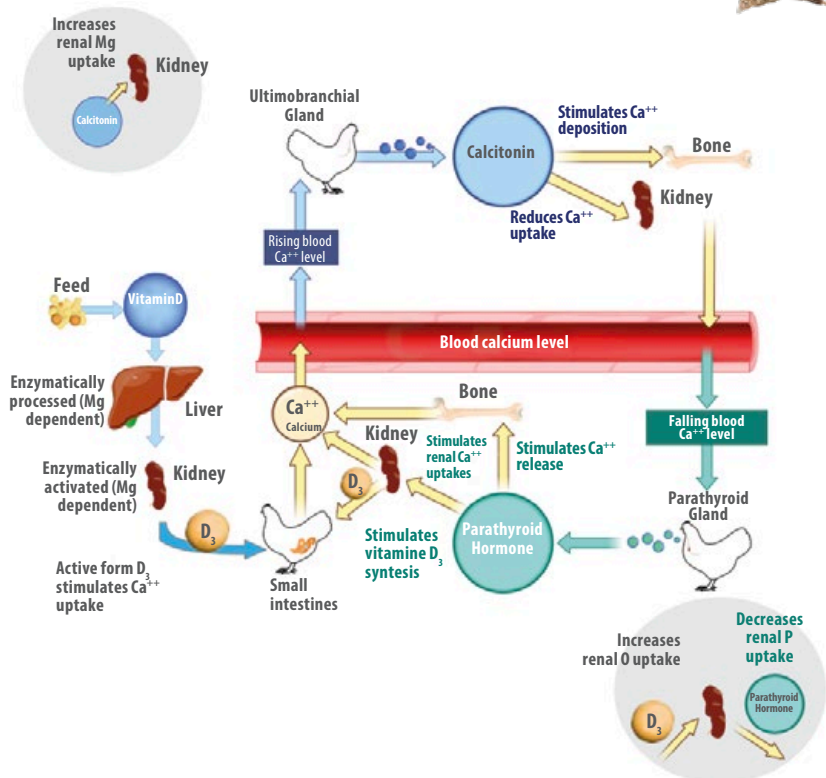
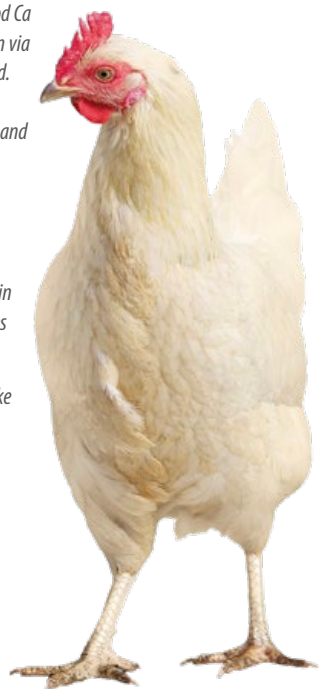
When body stores are low, gastrointestinal absorption, bone resorption, and renal reabsorption increase. Conversely, excreting and decreasing gastrointestinal absorption can reduce levels.

Figure 3. Center diagram: Calcium blood levels are controlled by hormones (Parathyroid Hormone (PTH) and Calcitonin). When blood Ca levels are low, PTH stimulates the absorption via the kidney and bone stores are also released. When blood Ca levels are high, calcitonin is produced. The kidneys reduce reabsorption and excrete excess.

Calcium can also be stored in the bones. Vitamin D, ingested with feed, can be processed through the liver and kidneys to the active form D_3 . The activation of Vitamin D requires Magnesium. Vitamin D_3 increases gastrointestinal absorption of calcium.

Inset top left: Calcitonin increases the uptake of magnesium.

Inset bottom right: Vitamin D_3 increases the renal sorption of phosphorus, while parathyroid hormone decreases renal reabsorption.



GASTROINTESTINAL ABSORPTION

CALCIUM

Factors *favoring* Calcium absorption

- ✓ Correct Ca to P ratio (no more than 2:1)
- ✓ Healthy intestinal tract
- ✓ Acidic pH (prevents complex formations and precipitation)
- ✓ Presence of organic acids
- ✓ High protein diet (Lysine and Arginine promote absorption)
- ✓ Presence of vitamin D

Factors *inhibiting* Calcium absorption

- ✓ Incorrect Ca to P ratio (1:2 inhibits Ca uptake)
- ✓ Poor intestinal health
- ✓ Alkaline pH (Ca will complex and precipitate)
- ✓ High dietary fat intake (forms calcium soaps that are excreted)

PHOSPHATE

The kidneys are the major regulator of phosphate blood concentrations, although regulation is also adjusted by intestinal absorption. Phosphorus is both actively transported and freely diffuses across the cells in the small intestines. For active transport, a sodium-coupled co-transporter is the major pathway. Expression and activity of this co-transporter is regulated by the availability of phosphorus. When phosphorus is restricted, there is an increase in activity and prevalence of transporters on the apical membrane of small intestine cells. If the demand for Pi decreases, excess is removed by the kidneys.

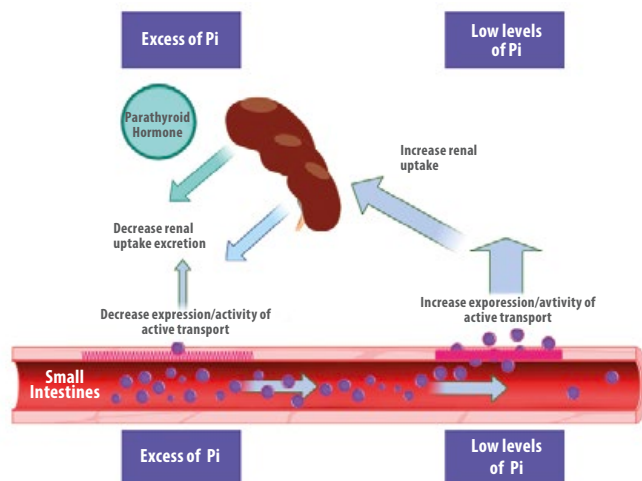


Figure 4. The kidneys are a major regulator of phosphorus by increasing or decreasing renal uptake. Intestinal absorption can be increased or decreased through the expression and activity of the active transporter NaPi-2b. Parathyroid hormone decreases renal absorption by decreasing the abundance of active transporters in the renal tubules.

SCIENCE BASED RECOMMENDATIONS

Calcium and Phosphorus ^{Ca} ^P

The nutritional needs of a bird are dynamic and, as such, feed formulations can either over or under supply some feed components depending on the bird's age and needs.

One solution is to use multiphase feeding so that, as the number of feed formulations increases, the ability to precisely provide the correct nutritional requirements also increases



Performance & Nutrition Supplement

Cobb500™ Broiler

Performance & Nutrition
Supplement (2022)



Our 2022 Cobb500 broiler supplement provides 5 different diet recommendations (starter, grower 1, grower 2, finisher 1, finisher 2) to target aged-based nutritional needs more precisely.

Compared to amino acid and energy nutrition research, there is considerably less information about mineral nutrition. Moreover, most nutritionists acknowledge that there are opportunities and needs for a better understanding of the effect of Ca and P on broilers performance.

Cobb Vantress has been actively researching the requirements of these minerals in broilers. Based on these research studies, in 2022, we published new recommendations of Ca and Available P for our Cobb500 Broilers.



SUMMARY



Through genetic selection, the Cobb broiler's growth and target body weight has accelerated during recent years.

Moreover, research has provided further insight into the interactions of calcium and phosphorus and their impact on performance. For these reasons, Cobb has published new guidelines for dietary inclusion of these feed components.

It is important to note that good nutrition is one part of being able to attain the full genetic potential of the Cobb broiler. A good management program must be in place. Our Cobb broiler supplement provides all the nutrition and performance guidelines.

The **Cobb Broiler Management Guide** is also available, which is designed to assist you in developing your management program.

References upon request

*Calcium and Phosphorus. A
necessary balance in broiler diets*

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TOGETHER, WE CAN MAXIMIZE GENETIC PROGRESS.



JOIN US.

The Cobb Research Initiative is a new program that seeks to further genetic progress and help answer key issues facing the global poultry industry. From disease prevention and enhancing animal health and welfare to advancing sustainability needs – we are seeking partnerships and researchers to help drive innovation.



Submit your pre-proposals electronically by April 3, 2023 at
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