ilc resources

MINERAL Writes

4th QUARTER 2012

In this issue:

Todd M. Owens, M.S., P.A.S.
Director of Nutrition and Technical Services
ILC Resources
3301 106th Circle
Urbandale, Iowa 50322-3740
(515) 243-8106
Fax (515) 244-3200
1-800-247-2133
www.ilcresources.com
toddo@ilcresources.com

A Balancing Act

Calcium and phytase are both important additives in poultry diets. Dietary calcium requirements in broiler physiology vary with age, the source of calcium and phytate content of the diet. As the industry comes to terms with the effects of drought conditions and high prices of commodities at year's end, it is important to remember that while both calcium and phytase are beneficial, there must be balance in the amounts included to achieve maximum growth and development potential. Both supplements are beneficial and offer several benefits depending on the dietary content.

Dietary calcium has been shown to increase pH in the gizzard and ileum in broilers and interferes with apparent ileal digestibility of phosphorous and crude protein. A recent study in the United Kingdom (Walk et al., 2011), looked at feeding phytase above industry recommendations and concluded that those higher phytase (up to 5,000 FTU/kg) amounts may be appropriate for low-calcium diets since broiler performance is maintained, and amino acid digestibility is improved. Complete phytate hydrolysis explains why reduced dietary calcium may not influence broiler performance.

Implications of high dietary calcium

High dietary calcium (up to 1.0% in poultry diets) may reduce phytase efficacy, reduce animal performance, increase gastrointestinal pH levels and interfere with macromineral absorption. Amino acid utilization is affected because high dietary calcium concentrations raise gastric pH and cause a direct reduction in protein digestibility because of reduced pepsin (digestive enzyme) efficacy. Pepsin is pH dependent in a chicken's proventriculus/gizzard, with optimum activity at a pH level of 2.8. As gizzard pH increases, calcium solubility in broilers is reduced and the higher pH levels indirectly influence calcium-phytate interactions (or precipitation) in the gastrointestinal tract.

The suggestion is that dietary calcium acts as an antacid in the digestive tract. The significance of an increase in pH from dietary calcium varies with the age of the birds. Digestive tract pH levels also vary widely between individual birds according to the research. More discussion follows in this article about gastric pH levels and the effect on chicken pepsin efficacy.

Since the effects of high dietary calcium can negatively influence broiler development and performance, nutritionists, producers and industry professionals have to decide if diets will be reformulated at lower levels of dietary calcium using a source from calcium carbonate or higher concentrations of phytase to hydrolyze phytate and reduce calcium-phytate interactions while maintaining broiler performance. It is also worth noting that phytase is beneficial when in the presence of reduced dietary calcium (0.64%) by regulating pepsin efficacy and improving amino acid digestibility by reducing the proximal gastric pH levels.

Continued on p. 4

Water as a Nutrient and the Minerals It Carries

Water is an important nutrient required by all animals. It can even be said that water is the MOST important nutrient. This is a broad overview of water as a nutrient and of the nutrients it carries. It plays a role in digestion and metabolism of nutrients, eliminating waste from the body through urine, feces and breathing. Water maintains cell structure, blood volume and pH levels. A body uses water in breathing and to control body temperature. This well known universal solvent acts as a lubricant in joints and between cells. Water is involved in transporting nutrients to and from cells while maintaining an electrolyte balance. While water is utilized in many ways by animals, it and the nutrients it contains can also be lost in significant quantities in a variety of ways.

Background

In a neonatal pig water makes up 80% of the animal's fat free body weight and a finishing pig's fat free body weight is 55% water. Most of the tissues in a body (animal or human) are 70-90% water. Blood composition is 90-95% water. The most common source of water in a diet is drinking (free-choice). There is moisture in dry feed. Between 9 and 13% of water is not chemically bound to nutrients and compounds in dry feed. A third source of water is metabolic, or is the moisture in feed that is chemically bound in the feed and released when digested or when body tissues are broken down at the cellular level. The amount of water available metabolically varies with the nutrient. For example, a gram of protein generates about 0.4 grams of water and a gram of fat releases 0.6 grams of water.

As a point of reference, the water requirements for pigs follow: newborn pigs require 46 mL/day; weanlings require an average of .94 L/day; grow/finish require 2.5 kg/kg of feed intake; gestation requires 13 L/day and lactating sows require 20 L/day. Water intake (L/day) can be calculated as 0.149 + (3.53*daily feed intake (kg)). Poultry water requirements vary with age, feed intake and bird type. In general at one week, broilers require 225 mL of water per week and newly hatched pullets require 200 mL per week. At four weeks, broilers need 1,000 mL per week and early growing pullets require 500 mL per week. Broilers require 2,000 mL/week at eight weeks and growing pullets require 800 mL/week. These prelayers also require 1,000 -1,300 mL/week between 10 and 18 weeks.

Water is the universal solvent. This is why you can find more than just hydrogen and oxygen in water. It is generally assumed that 100% of the nutrients dissolved in water are available to animals. Mineral salts dissolve and dissociate into ions in the fluid. To maintain balance in an animal's system, water is attracted to the electrolytes and follows them. Proteins are used to regulate the flow of water/fluids and ions.

Water may be a major source of minerals and nutrients in an animal's diet. In fact up to 20% of water may contain minerals and nutrients. These concentrations may be substantial amounts, but unfortunately the water is usually unpalatable at these levels. The elements and compounds in water affect the quality of water. Water is essential to many metabolic reactions in a body. Ideally, the water available to livestock and poultry should be clean and free of microbial contamination. The total dissolved solids (TDS) in water affect water's odor, taste, appearance, physical and chemical properties, the macro-and micro-mineral content and the presence of toxic substances. Clean, ideal water has TDS levels at less than 1,000 ppm. At a level of 2,000-3,000 ppm in water, you may observe diarrhea and temporary water refusal. Water is refused and should be avoided for breeding stock when TDS levels are greater than 5,000 ppm and at over 7,000 ppm, water quality is deemed unsuitable.

Water hardness is another property of water that is a measure of calcium and magnesium ions in water. Hardness is classified as soft at 0-60 ppm; moderately hard at 61-120 ppm; hard at 121-180 ppm and very hard at greater than 180 ppm in water. Studies have found that water hardness of up to 290 ppm does not appear to affect water intake and milk production in dairy cattle. Other nutrients that may contribute to water hardness are zinc, iron, strontium, aluminum and manganese, but they are generally present in low concentrations.

Nitrate and sulfate levels in water may or may not be detrimental to animals, depending on their concentrations and compositions. Nitrates may contaminate drinking water from surface or shallow ground water. Nitrate poisoning is the result of nitrate being reduced to nitrite in the digestive tract and then entering the blood stream. The oxygen-carrying capacity of the blood is

Continued on p. 3

Water as a Nutrient — *Continued from p. 2*

then reduced. Nitrate levels have an effect on reproductive performance over time in dairy cattle according to research or where nitrate-nitrite levels are high (approximately over 20 ppm nitrate/nitrate). High concentrations of sulfates in water may produce a laxative effect in animals. In time, they tend to acclimate to the water composition and the diarrhea is no longer apparent. Calcium, iron, magnesium and sodium salts are common forms of sulfates in water. Like hardness, the effects of sulfates on animal performance vary with and depend on the composition and concentration of the sulfates that are present. Hydrogen sulfide is less common in water, but is the most toxic form of sulfates. Concentrations over approximately 0.1 ppm of this compound produce a rotten egg smell.

While water quality is known to affect consumption and palatability in humans, the affect is not as clear in animals. Some minerals (like nitrates and sulfates), microbial contamination and organic compounds can affect both human and animal health. Research is limited that directly links iron and manganese to reduced water consumption and lowered milk production in dairy, although those elements are associated with many water quality issues. Questionable water quality is often identified by the observation of the animals that don't seem to be drinking "enough" and production or growth is less than expected.

As an example, water consumption by dairy cattle is influenced by the dry matter intake, ingredient composition of the diet, percentage of dry matter in the diet, milk production, environmental conditions and nutrient content of the diet (specifically sodium, salt and protein). Dairy cattle only spend 12 to 15 minutes per day drinking water. Most of this time is immediately after milking and during feed consumption. Cows consume on average 4 liters per minute in tie stalls and 11 to 19 liters per minute from troughs in loose housing. This consumption is in direct proportion to physiological needs (milk production, maintenance, growth and gestation).

Research

A study conducted by University of Minnesota Extension looked at the macro-mineral intake and impact of minerals in waters on the daily absorbed requirements of a dairy cow. The study was based on a water consumption of 108 liters, 38kg of milk production and 23 kg of dry matter intake. The study assumed that 100% of the minerals in water are available to the animal. As an example, if this water sample has an average of 80 ppm of calcium in the water, for a dairy cow that translates to an average of 8.6 g/day or 9% of the dairy cow's daily absorbed requirements for this macro-nutrient. For magnesium, this sample contained an average of 50 ppm, 5.4 g/day or 67.3% of the daily requirements.

Producers, nutritionists, and other industry professionals spend a great deal of time and effort focusing on nutrient availability in the diet. It is important that we do not forget about water as nutrient. It is essential to many physiological and metabolic functions in the body. It also serves as an excellent source of many macro- and micro-nutrients necessary for milk production, maintenance, growth and gestation. While our animals may not drink eight glasses a day, they will take in the water they need and this source provides an essential nutrient with minerals to their diet.

As feed costs continue to rise, it is prudent to remember that in addition to the vital role water plays in animal growth and development, it will also serve as a source of key nutrients and minerals. It will provide producers with a viable alternative to supplemental minerals as they face economic and environmental challenges to produce more with less (land, feed, chemicals, etc.). The potential water has and the necessity of this nutrient will also demand continued consideration as competition for water increases among the world's rising population.

Information for this article was taken from Impact of minerals in water on dairy cows *by Jim Linn,, published in* Dairy Star, *November 17, 2008. Additional information from* Dr. Chris Hostettler, *Director, Animal Science and Technology, National Pork Board.*

The Staff at ILC Resources wish you Happy Holidays and Best Wishes for a Successful 2013!

Calcium is a limiting factor in broiler tibia ash assays. Significant reductions in tibia ash were observed when incorporating reduced calcium levels (0.64%) in the trial diets, although no influence was noted on the broilers growth performance. The tibia ash assay is a more sensitive indicator of mineral status than growth performance and thus more definitively proves the impact of dietary calcium. Calcium to phosphorous ratios have been postulated to affect increases in the percentages of tibia ash as dietary calcium. When broilers were fed low calcium with low phosphorous diets (1.1:1, Ca:P ratio) broiler weight gain or toe ash improved 24% improved 15%, respectively, (Qian et al., 1997), on diets of high calcium with low phosphorous (2.0:1 Ca:P ratio).

High levels of supplemental phytase implications

High levels of supplemental phytase may increase gastric pH levels by breaking down the phytate molecule. By chelating molecules, and thereby reducing digestibility and increasing mineral excretion of calcium, sodium, or phosphorous for example, phytase may be a factor in reducing the dietary electrolyte balance. This would create a more acidic environment in the gastrointestinal tract. Phytase supplementation is more effective in phosphorous deficient diets than in P-adequate diets. The authors of the UK study hypothesize that reducing dietary calcium may improve phosphorous digestibility by reducing the formation of insoluble Ca-phosphate complexes.

The study conducted in the UK found that broiler feed intake and body weight gain will not be influenced by dietary calcium or phytase. The authors suggested that calcium and phosphorous were not limiting growth factors in the birds. Consistent with other studies that have shown linear improvement in body weight gain as dietary calcium increases from 0 to 1.0%, this study found that phytase supplementation improved body weight gain in low calcium diets. These results may imply that the addition of phytase improves calcium utilization through phytate hydrolization.

At 5,000 FTU/kg of supplemental phytase, apparent ileal digestibility of amino acids improved in this study. This finding duplicated findings from previous studies on feeding supplemental phytase. Specifically, the apparent ileal digestibility of serine, tyrosine, and total crude protein was improved and the digestibility of arginine, leucine, phenyalanine, glutamine and proline tended to improve at 5,000 FTU/kg of dietary phytase. The latter grouping of amino acids improved only when the broilers were fed a higher level of calcium (1.03%). The amino acids particularly affected by calcium and phytase were serine, glutamine, leucine and tyrosine (which are major components of chicken pepsin). The pH-activity of pepsin is between 1.8 and 5.0, optimally at 2.8. This finding suggests that pH may impact pepsin activity, which will influence the interaction between dietary calcium and phytase on amino acid digestibility. Gastric pH levels also influence Ca-phytate interactions, phytate interference with pepsin activity, and how calcium influences phytase efficacy and these factors affect protein digestibility in the gizzard and amino acid digestion.

Noteworthy Findings

This study concluded that feeding low calcium diets (0.64%) did not affect growth performance of broilers from 1 to 16 d of age, but did present reduced broiler tibia ash (an indicator of mineral status). Feeding above recommended levels of dietary phytase improved broiler feed conversion rate, tibia ash and amino acid digestibility in both high (1.0%) and low (0.64%) calcium diets. These findings are due in part to the significant effect that phytate, phytase and calcium have on gastrointestinal pH levels. Hydrolyzed phytate, (a result of high doses of phytase), may be acidogenic and may move gastric pH closer to the pepsin pH optima of 2.8. This movement then improves pepsin efficacy and apparent ileal amino acid digestibly and reduces endogenous pepsin secretion.

What this means

Higher than industry recommendations of phytase doses may allow the feeding of reduced calcium diets while maintaining broiler performance and bone ash, and improve amino acid digestibility. Phytase is more effective in phosphorous deficient diets than in phosphorous adequate diets. Understanding the nutrient composition of diets is crucial as the balance between these dietary supplements has significant consequences for broiler development and growth. As we move forward in animal production, our industry will have to adapt to the new technology and its implication to cost on production. As the world population grows so will the impact of improving feed efficiency. We continue to search for ways to improve nutrient density and balance.

Information is taken from:

Walk, C.L., M.R. Bedford and A.P. McElroy. 2011. Influence of limestone and phytase on broiler performance, gastrointestinal pH, and apparent ileal nutrient digestibility. Poultry Science. 91:1371-1378. http://dx.doi.org/10.3382/ps.2011-01028.

Qian, H., E.T. Kornegay, and D.M. Denbow. 1997. Utilization of phytate phosphorus and calcium as influenced by microbial phytase, chole-