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Enzymes in Diets with Dried Distillers Grains

Grain prices are always a concern. Producers are continually looking for ways to reduce feed costs and are still expecting to provide optimal nutritional requirements. Enzyme supplementation is one way of meeting these demands. These enzymes increase the availability of many nutrients, including phosphorous, calcium, apparent metabolizable energy (AME), and also improve nitrogen retention (Cowieson and Ravindran, 2008). Another option includes alternative ingredients like dried distiller grains with solubles (DDGS). In layers, DDGS have been found to be an alternative to replace corn, soybean meal, dicalcium phosphate and salt (Masa'deh et al., 2011).

When DDGS were added to the diet, exogenous enzymes improved production by increasing the digestibility of low-quality feed ingredients and reduced nutrient loss via excretion (Costa et al., 2008). One example of the nutritional benefits offered through enzyme supplementation is increasing the availability of the nonstarch polysaccharides (NSP) for use by the birds (Buchanan et al., 2007). In diets that contain wheat and barley, NSP is a factor in gut viscosity. This is something to consider with corn and soybean diets as well, since they also contain varying NSP levels.

Incorporation of NSP provides more dietary energy and decreases gut viscosity. When NSP compounds are present in the gut, they have the capability to encapsulate nutrients which makes them less available to the birds. Specifically wheat and barley diets require consideration in terms of NSP, but even corn-soy diets warrant attention due to the varying NSP levels in corn and soybeans (Meng and Slominski, 2005).

Dried distillers grains with solubles are another diet ingredient that influences the effect of NSP. As a result of the DDGS processing, they contain greater amounts of protein, fat, minerals and NSP than the original corn starch. This makes DDGS a key component in least-cost diet formulations. Increased NSP levels are the main limiting factor of DDGS availability in poultry rations (Oryschak et al., 2010) because the fiberous NSP is not efficiently digested by poultry. As alternative feed ingredients are identified it is important to determine the appropriate standards for meeting and balancing nutritional requirements with production costs. Oryschak et al., (2010) determined that 15% is a maximum inclusion rate of DDGS.

One recent study at the University of Nebraska (Hahn-Didde and Purdum, 2014) looked at the effects of xylanase, amylase and protease supplementation in moderate- and low-metabolizable energy diets that contained DDGS in laying hen diets.

Continued on page 3

Phytase effects throughout the gastrointestinal tract in pigs

Minerals are not absorbed uniformly throughout the digestive tract. Different minerals are better absorbed at different locations depending on what ingredients are fed, how they interact with each other and if that interaction occurs before the animal consumes the feed or if it happens in the gastrointestinal tract (GIT). One example is Phytate, which interacts with the divalent cations, (specifically Ca). This interaction can reduce mineral absorption.

Phytase improves nutrient availability. It can be found occurring naturally as microbial phytase in the gut micro biota in the GIT (Leytem and Thacker, 2010), as an endogenous phytase in plants (Schlemmer et al., 2001) or is commercially available as a dietary supplement. Many recent studies have looked at how phytase frees up Ca and P. The drawback to some of those studies is that they looked at how the nutrients disappear across the total tract and to a limited extent the apparent ileal mineral absorption. Since absorption of nutrients released at the end or after passing through the ileum into the hind gut are poorly absorbed, it is very important for calcium and phosphorus to be released early in the GIT.

Experiment

Rutherfurd, et al. (2014) specifically conducted research to study degradation of phytate P and apparent digestibility of total P and Ca as they respond to microbial phytase in corn-soybean diets fed to pigs. They were also able to study the impact of phytase supplementation on bone mineral density (BMD).

There were 32 male pigs in this experiment. Four diets were used; two as positive and negative controls and two as test diets. The first was formulated to be adequate in total P and Ca (positive control). The second was deficient in total P and Ca (low-P, negative control). The third and fourth diets were variants on the second (low-P) with varying amounts of microbial phytases added (1,107 U/kg or 2,215 U/kg respectively, U represents units of the nutrients).

Findings

The phytase supplementation significantly ($P < 0.05$) increased the bone mineral content (BMC) and BMD in the radius, ulna and metacarpals. The increases were dependent on the levels of phytase included. The BMD in hogs fed the supplemented low-P diet was almost equal to the hogs fed the positive control diet. This supported other studies (Pagano et al., 2007) that have found supplemental phytase improved bone strength.

There was an interaction ($P < 0.001$) between diet treatment and the GIT region where digestibility occurred for both the degradability of phytate P and the apparent total P digestibility. There was no significance for phytate P degradability in the control diet and the low-P control diet at the gastric, jejunal and ileal levels in the digestive tract. On average, 33% of P was degraded in the control and low-P diets at the gastric, jejunal and ileal levels. Across the total tract, on average 87% of phytate P was degraded on those diets.

Between the test diets with the two levels of phytase inclusion, there was no difference on phytate P degradation throughout the GIT locations. Phytate P degrability was higher at the jejunal and ileal levels compared to the gastric level, which was less than over the total tract ($P < 0.05$). The differences between phytate P degradability at the ileal level compared to the total tract on each diet were 57%, 48%, 27% and 26% units on each diet (the positive control, low-P, and the two phytase-supplemented low-P (treatments respectively).

Specifically at the gastric level, dietary phytase supplementation did not affect phytate P degradability ($P < 0.897$), but the average values were large (22-39%). There was a significant difference ($P < 0.001$) between the supplemented and unsupplemented diets with greater levels at the ileal and jejunal locations compared to over the total tract. The increase due to the supplementation varied at each point over the GIT. The percentages were 41, 34, and 9 at the jejunal, ileal and total tract respectively.

Apparent P digestibility was affected by the interaction between diet and GIT level. Apparent total digestibility levels were low in the stomach with no difference between the diet treatments. Levels increased from the stomach to the jejunum and then from the jejunum to the ileum ($P < 0.05$) on the phytase supplemented diets compared to the unsupplemented diets. In the stomach, phytate P was hydrolyzed to a significant extent across all diets. This has been established in studies on hogs fed corn based diets (Pontoppidan et al., 2012). In that experiment the researchers suggested that phytate P was hydrolyzed in the stomach because plant phytases were naturally present.

In addition, the apparent Ca digestibility was influenced by diet and GIT region. On all diets, the gastric apparent Ca digestibility was lower ($P < 0.05$), and there was no difference between diets for Ca digestibility between the jejunal, ileal and total tract. Phytase supplementation increased Ca digestibility ($P < 0.05$) compared to the control diets. Calcium absorption occurs mainly in the proximal small intestine. The phytase supplementation in this experiment improved apparent Ca digestibility to the end of the jejunum.

What this means for the industry

Continued on page 4

Enzymes in Diets with Dried Distillers Grains

Experiment

The researchers strived to determine if lowering the amount of metabolizable energy (ME), P, and Ca with and without the addition of enzyme supplementation affects production parameters and nutrient retention in layers. They used 192 Hy-Line W-36 white leghorn laying hens in the experiment. Birds had daily access to 100g of feed per hen. Diets were formulated into two experimental treatments fed in two phases. Phase 1 was fed from 25 to 36 wk of age and phase 2 was fed rom 37-51 wk of age. Researchers recorded weekly feed intake and daily egg production. Feed intake was calculated on a per hen per day basis and egg production as a percent of egg production per hen per day.

Diets were formulated on the expected feed intake and age of the birds (25-51 wk). The variables in the experiment were the Avizyme 1502 enzyme complex (at levels of 0 or 0.0375%,) and the ME levels (moderate or low). Phyzyme XP 5000 G at 300 FTU/kg (phytase) was added to all diets.

Moderate-ME levels were 2,900 kcal/kg in phase 1 and 2,880 kcal/kg in phase 2. Low-ME levels were 2,860 kcal/kg and 2,800 kcal/kg in phase 1 and phase 2 respectively. The experimental diets were moderate-ME, moderate-ME with 0.0375% Avizyme 1502, low-ME, and low-ME with 0.0375 Avizyme 1502. Avizyme 1502 will be referred to as the enzyme complex in this disussion. Avizyme 1502 contained 225 units/g of xylanase, 300 units/g of amylase and 3,000 units/g of protease and contributed 87 kcal/kg to the diet. The DDGS were added to all diets at 15% with a calculated value of 0.42% available P. The diets were formulated to contain 0.33% P and Ca at 3.79%. Phytase was calculated to provide 0.12% available P and 0.108% Ca.

Findings

In terms of production, there was no significant interaction between the enzyme supplementation, ME levels and time overall. However, during the last two weeks of phase one, the birds experienced heat stress when the housing unit temperature exceeded 35°C. Egg production during this time was higher on the diets with low-ME levels (see figure 1). The researchers found that during heat stress, egg production levels were more dependent on dietary ME levels compared to the enzyme combination. Also, the hens on the low-ME diets (2,860 kcal/kg) consumed more kilocalories per hen per day ($P \leq 0.0291$). This prompted the researchers to suggest that during heat stress, hens fed a low-ME diet will be better able to maintain higher egg production. For feed intake, when determining the kilocalories per hen per day consumed during the period of heat stress, all hens had similar energy consumptions on all diets. This further supports the theory that laying hens will consume feed to meet their energy requirements (Hill et al., 1956).

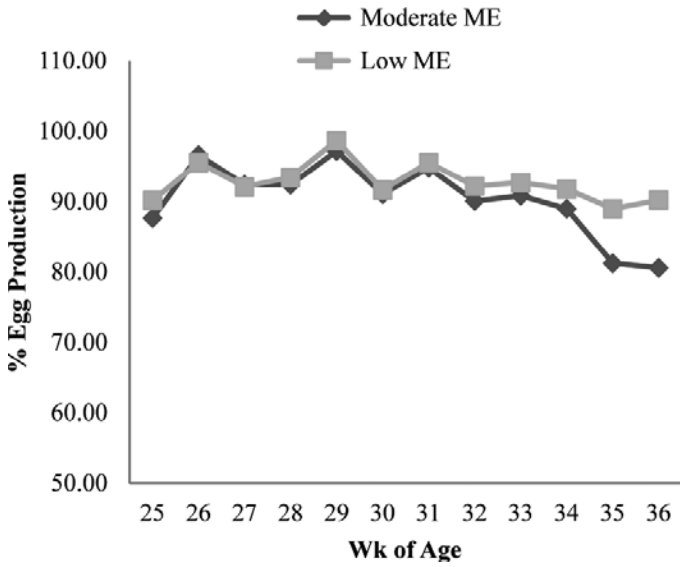

Figure 1. Egg production through phase 1 (25–36 wk of age; $P \leq 0.005$), howing that from 32 to 36 wk of age egg production was higher for birds fed diets containing low ME than for birds fed moderate ME. SEM = 0.015

In phase 2, the interaction between enzyme supplementation, ME level and time became more significant ($P \leq 0.065$) indicating a trend for hens on diets containing the enzyme complex, phytase and low-ME levels to have a higher feed intake. Given that the differences in this study were so small, the researchers suggest that the enzyme effect may be influential, since enzyme complexes and phytase can recover otherwise unavailable energy in the diets.

Calcium retention was significantly higher in diets containing the enzyme complex, specifically the moderate-ME diets. There was also a difference between the diets for P retention and the average values were low in phase 1. This may be due to the influence of the heat stress experienced by the birds. Both diets without the enzyme complex reported higher P retention diets during this phase. In phase 2, the diets with the enzyme complex reported the higher P retention values. This is evidence that enzyme supplementation will have a positive effect on mineral retention.

What this means for the industry

This research proves that continued efforts to identify alternative feed ingredients due to cost considerations are a feasible production option. The alternatives will be most beneficial with enzyme supplementation when Ca, P and ME are limited in their availability. This is because enzyme supplementation has been shown to restore ME levels and increase absorption levels of Ca, P, crude protein and AME. It is important to note that other factors also influence production since during the period of heat stress

Continued from page 1

Continued on page 4

Enzymes in Diets with Dried Distillers Grains

in this experiment the hens fed low-ME diets experienced higher egg production and outperformed the hens on moderate-ME diets regardless of the enzyme supplementation.

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Phytase effects through the GIT

Research is still being done to determine how supplementation of microbial phytase in the diet affects phytate degradability in growing pigs. The current study lends credence to the hypothesis that micro biota in the large intestine are largely involved in phytate hydrolysis. This is evident since there was greater hydrolysis occurring in the hindgut for the unsupplemented diets. The evidence also supports that most of the total amount of P appears to be absorbed in the jejunum. An even greater proportion of total P was absorbed on the phytase-supplemented diets. The greater release and availability of P from phytate in the presence of phytase occurred to the end of the jejunum. There are many differences between the studies on this subject, but it is becoming clearer where exactly along the GIT phytase supplementation allows for the greatest absorption of hydrolyzed phytate P occurs. This study found a considerable amount was hydrolyzed in the hindgut, but little or no P was absorbed at this point, which means the phytate P was excreted and unavailable as a nutrient.

Rutherfurd et al., (2014) suggested that total tract P digestibility estimates may be adequate for determining total P availability in the diet, but ileal estimates of phytate P degradation may more accurately predict how much digestible P is derived from phytate. The total tract estimates include amounts that result from hydrolysis of phytate by hindgut microbes that confound those estimates since it results in an inflated calculation of P. When calculating P availability, placing more emphasis on the location, (i.e., the small intestine) where P degradation occurs with the highest estimate of digestibility will allow diets to be more accurate and productive. This method of calculation also allows for P degradation that occurs in the stomach.

Supplementing a low-P corn-soybean meal diet with microbial phytase increases phytate degradation at the end of the ileum in growing pigs. Phytate was also hydrolyzed in the hindgut, and Rutherfurd et al., (2014) suggest that was due to the microbes in the hindgut. It is important to recall that the P released in the hindgut was not absorbed by the animal. This fact justifies the use of ileal estimates of phytate P degradation to more accurately measure the availability of phytate P in the diet compared to using total tract estimates.

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Continued from page 3

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The Staff at ILC Resources wish you Happy Holidays and Best Wishes for a Successful 2015!

Continued from page 4

Genetics vs. Nutrition

Over the years, livestock production has focused on selective breeding through genetics for faster and bigger growing broilers. While the arguments for this development are sound, the same efforts have not followed through on developing birds with the bone structure to support this increased weight load. The bones in fast growing broilers are porous. The increased weight in a short amount of time results in fractures and chronic pain in leg bones, which leads to mortality and economic loss. Previous studies (Venäläinen et al., 2006; Thorp and Waddington, 1997; and Williams et al., 2000) suggested the relatively low mineral content in heavily selected broiler genotypes may be apparent because current diets standards are not formulated to adjust for the increased mineral requirements of fast growing genotypes.

Shim et al. (2012) recently conducted a study to specifically look at the bone abnormalities of fast-growing broilers. They looked at leg morphology, tibia breaking strength, tibia density, tibia mineral content and tibia ash in both fast growing (FG) and slow growing (SG) birds of the same strain (Arkansas randombred chickens). The chemical and physical structure of bones has been studied extensively because of the significance of mineralization of the bone matrix. It is the mineralization that affects bone strength. Strength is determined by the volume of bone tissue, how the tissue is architecturally arranged on a microscopic level, and the degree of mineralization (Boivin and Meunier, 2002). Breaking strength, bone density and bone ash are well established markers of bone status based on mineral nutrition concepts. Bone density is the weight of mineral per volume of bone. This is calculated by how many mineral atoms are deposited within the bone matrix and how porous the resulting matrix is. Determining bone density indirectly determines bone strength, but the method cannot be used in living beings. Bone ash measures the mineralized bones. The amount of ash is proportional to the degree of bone hardness (Bonser and Casinos, 2003). Bone ash also establishes the organic component of bones which indicates tensile strength and flexibility (Velleman, 2000).

Experiment

Arkansas randombred chickens are a random-mating broiler control line. There were two subgroups; one was classified as slow-growing (n = 511) and one was fast-growing (n = 545) as determined by their growth rate between hatching and 6 weeks of age. Body weight was recorded at hatching and at 6 weeks. The birds were fed mash starter diets up to 18 days of age and then switched to a pelleted grower diet. The mash diet contained 9.5 g/kg of Ca and 7.2 g/kg of total P. The pelleted diet had 9.0 g/kg of Ca and 6.7 g/kg of total P. Average growth rates were

Continued on page 6

Genetics vs. Nutrition

230.6 g/wk for the slow growing birds and 318.4 g/wk in the fast growing birds. At the end of the experiment (6 wk) the body weights were 1.4 kg and 1.9 kg for the slow growing and fast growing birds, respectively. Right tibiae were measured for tibia weight, length, diameter and breaking strength. Left tibiae were measured for tibia mineral density, content and ash.

Findings

Shank (g, mm), drum sticks (g), thigh (g) and tibia (g, mm) measurements were lower in SG birds compared to FG broilers. The SG broilers also had lower amounts of tibia breaking strength (kg), tibia mineral density (g/cm^2), and tibia mineral content (g). Tibia ash content (%) was not different between the two groups. Based on body weight units, the SG broilers had higher shank length and diameter, and also higher tibia length and diameter over FG broilers with no differences between the groups for the weight of the tibiae. Tibia breaking strength, tibia density and tibia ash content were also significantly higher in the SG broilers. However, the tibia mineral contents were significantly lower (P = <0.0001) in the SG broilers.

What this means for the industry

Over the last 50 years, the selection for growth has also affected the overall bone quality in broilers. Overall this has been positive and the absolute values of bone measurements have significantly increased and improved. Specifically however, the shank and tibia measurements were found to be better in the slower growing broilers for the increased load they carry. The FG broilers face a higher risk of bone breakage. Bigger broilers carrying more muscle tax the bird and can cause weak and unhealthy legs.

The recent study (Shim et al., 2012) pointed out that FG broilers may not want to walk or exercise and that the time laying down increases with age. In this study, the FG and SG broilers were raised together so that leaves genetic differences in the legs as the only plausible explanation for the findings.

Genetics is only part of the puzzle in bone development. Selection processes are currently incorporating skeletal integrity throughout the industry. In addition though, bone development is affected by nutrition and management systems and the interaction between all of the influencing factors. Leg abnormalities are a major cause of economic loss. They result in culling, mortality, reduced feed efficiency and growth and down-grading at the processing plant. Sullivan (1994) estimated that skeletal issues cost $80-$120 million dollars in the United States. Today that translates to a $127-$345 million dollar calculation (CPI Index, 2012). There needs to be continued diligence between all of these factors (genetics, nutrition and management) to find the ideal breeding balance for increasing growth and leg strength. Additional research related to calcium and phosphorus levels needs to be conducted as to how those concentrations in broiler diets address bone strength and integrity before arbitrary changes are made to the NRC requirements.

Continued from page 5

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