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The Influence of Calcium Levels on Phosphorus Digestibility and Retention in Broilers

There are many different values for phosphorus availability in feedstuffs. The differences may be because of the different ways to calculate phosphorus availability. To set a standard, the World Poultry Science Association has formed a Working Group that proposes determining phosphorus utilization using a true ileal (prececal) phosphorus digestibility method (TIPD) to report true phosphorus retention (TPR) and TIPD values together (WSPA, 2013). The influence of post-ileal microbial fermentation is not present when calculating phosphorus utilization using TIPD and the TPR method demonstrates whole-body phosphorus digestibility, metabolism and excretion. Based on these assumptions, it seems logical that dietary phosphorus concentrations would be calculated to be the same, regardless of the method used, if diets are formulated below the requirement of the animal (Shastak et al., 2012).

Recent research shows the data to be inconsistent (Liu et al., 2013). It could be that dietary calcium concentrations are responsible for the variations in feedstuffs values between the two calculating methods (Mutucumarana et al, 2015). Different Ca:P ratios influence true phosphorus utilization in soybean meal, but the same research shows negative endogenous phosphorus losses (EPL) with both methods, regardless of the Ca:P ratio (Liu et al., 2013). Previous research has also found that EPL can be affected by the dietary Ca content and experimental P sources (Dilger and Adeola, 2006). There is not a great deal of published research on how dietary Ca influences the TIPD and TPR values of corn. Since corn is a mainstay in poultry diets, such research must be undertaken. This will help us understand the influence of Ca feeding strategies on TIPD and TPR and make predictions for EPL.

Experiment

Perryman et al. (2016), conducted an experiment to look into these questions. The researchers used 960 Ross x Ross 708 male broilers. They formulated experimental diets with 3 different dietary Ca concentrations of 0.95%, 0.13% or differing Ca concentrations to maintain a 2.1:1 Ca:P ratio and contain 0, 25, 50 and 75% corn. The control diet was a corn-soybean meal diet at a 1.4:1 Ca:P ratio. The birds were fed a common starter diet; and then, were fed the experimental diets from 19 to 26d of age.

The P concentrations of corn in the experimental diets were 0.06, 0.13, 0.20 or 0.27%. The NPP (non-phytate phosphorus) concentrations were 0.03, 0.04, 0.05 or 0.06%. The experimental diets were deficient in P to meet the requirements for the digestibility and retention lab tests (Rodehutscord, 2009). Dicalcium phosphate was a source of inorganic P in the control diet to maintain the Ca:P of 1.4:1 and Ca:NPP ration of 2.1:1.

Findings

The concentrations of crude protein and P were similar to NRC (1994) standards in the corn source of the experimental diets. The values of phytate P were slightly higher and the NPP concentrations were lower than NRC reports (1994). The analyzed nutrient composition of the corn source, on an as fed basis, is reported in Table 1.

Table 1. Analyzed nutrient composition of corn used for the determination of P availability.[1]

Item (g/kg, as-fed basis, unless otherwise noted)	Corn
Crude Protein[2]	81.8
Total P	2.74
Phytate P	2.37
Non-Phytate P[3]	0.37
Phytase activity (FTU/kg)[4,5]	<50.0

[1] All analyses were performed in quadruplicate.
[2] Crude protein determined by AOAC International method 990.09 (2006).
[3] Calculated as the difference between total P and phytate P.
[4] Phytase units per kg of corn determined by AOAC International method 2000.12 (2000).

Feed intake and growth performance are presented in Table 2. On the control diet, the body weight gain was lower (44 g/bird/d) but feed intake was in agreement with the breed performance guidelines for Ross 708 Broiler Performance Objectives (2007, 116g/bird/d). The control diet values were significantly higher than the feed intake and body weight gain in the birds on the experimental diets. As corn concentrations increased, the researchers did not observe any significant effects on feed intake response. Body weight gain trended to increase as corn levels increased, as dietary Ca was maintained at 0.13%. As P increased with the increasing corn levels in the experimental diets, the Ca:P shrank from 2.1 to 0.5, which may mean more P was likely available to the bird for growth.

The apparent ileal P digestibility (AIPD) and APR values of diets were similar between the birds on all the diets. There were no observed effects on AIPD or APR as P increased related to the increasing corn inclusion rates, regardless of the dietary Ca concentrations.

The AIPD ranged between 23.9 and 61.3%, and these are lower than values reported on varying corn diets by Mutucumarana et al. (2014). The Apparent P retention values varied between 38.5 and 75.3%. These values are similar but more variable than what Mutucumarana et al. (2014) found. This is most likely because of the differences in the Ca concentrations of the diets. There is a significant interaction for APR between the increasing corn and dietary Ca concentrations. The fixed Ca:P ratio of 2.1:1 diet decreased APR as corn increased, but APR values were not influenced by the increases in corn in the diets formulated with 0.13 or 0.95% Ca. The Ca:NPP ratios became greater because of the differences in corn phytate P and NPP concentrations. Increasing dietary Ca had a significant negative effect on AIPD.

On the control diet, the birds had greater P in the excreta and ileal digesta compared to the experimental diets. The increased dietary P concentration and higher feed intake led to an increased P intake. Supplemental corn in the experimental diets increased P output in both digesta and excreta. Phosphorus output increased linearly as P intake increased.

The TIPD and TPR of corn were different between broilers on the varying Ca feeding strat-

Table 2. Growth performance and feed intake (19 to 26 d of age) of Ross X Ross 708 male broilers receiving experimental diets varying in Ca and corn inclusion concentrations.[1,2].

Ca Feeding Strategy	Corn Inclusion, %	BW Gain, g/bird/d	Feed Intake, g/bird/d
Ca:P = 2.1:1	0	9.3	86.2
	25	17.6	87.2
	50	16.2	83.6
	75	11.6	79.5
Ca = 0.95%	0	6.0	82.0
	25	8.1	82.3
	50	7.8	79.4
	75	11.1	80.1
Ca = 0.13%	0	9.3	86.2
	25	18.9	88.3
	50	21.8	87.8
	75	15.5	85.2
Control		44.3	115.6
SEM		1.8	3.3
		Probabilities	
Contrasts			
Control vs. Treatment Diets		<0.001	<0.001
Ca:P = 2.1:1			
Linear		0.89	0.09
Quadratic		0.31	0.23
Ca = 0.95%			
Linear		0.09	0.21
Quadratic		0.37	0.60
Ca = 0.13%			
Linear		0.53	0.67
Quadratic		0.03	0.34

[1] Each value represents the least square mean of 8 replicate cages with 10 broilers per cage.
[2] The treatment with Ca = 0.13 and 0% corn was the same as the dietary treatment with a Ca:P = 2.1 and 0% corn

egies. True P retention values were higher than TIPD values when Ca concentrations of the diet were fixed at either 0.95% or 0.13%. This is indicative of possible post-ileal absorption of P for broilers fed diets with fixed Ca concentrations. While earlier research has shown that adding Ca to diets deficient in Ca improved P retention, the current research found TPR values were not influenced by feeding diets with 0.13% Ca.

What this means for the Industry

This research shows that lower (0.13%) dietary Ca levels increase TIPD and TPR compared to diets with a high Ca concentration (0.95%). Fixed Ca:P ratios influence post-ileal P retention and may cause estimates of EPL to be negative. The digestibility of calcium from different sources may contribute to differences in TPR when diets are formulated with very low concentrations. The analysis may also be limited when broilers have a longer (>6 d) period to adjust to Ca-deficient diets.

The negative EPL in this experiment may explain the lack of the significant differences between TRP and TIPD when diets are formulated to a fixed Ca:P ratio. The indigestibility of P may predict negative EPL, depending on the basal protein source and P ingredients. It is not possible to directly determine the decreases in P availability due to varying corn concentrations in diets by predicting negative EPL without more research.

Formulating diets with low Ca concentration (0.13%) may lead to overestimating the true P utilization (TPU). The analysis method used to determine TPU has limits when formulating diets with a fixed Ca:P ratio. It may also be limited in practical applications when dietary Ca concentrations exceed 0.70% (Ross 708 Broiler Nutrition Specification, 2007).

More research needs to be conducted to determine what the standards are and to gain a better understanding of the effect Ca concentrations have on P utilization. Since corn is a staple in poultry diets and in increasing amounts increases Ca concentrations, this is a cautionary example of considerations to keep in mind when formulating diets for peak production in poultry.

Information for this article taken from:

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