Animal Feed Science and Technology 238 (2018) 9–17

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Impacts of age and calcium on Phytase efficacy in broiler chickens

W. Li[a,1], R. Angel[a,*], S.-W. Kim[a], E. Jiménez-Moreno[a,2], M. Proszkowiec-Weglarz[a,3], P.W. Plumstead[b,4]

[a] Department of Animal and Avian Sciences, University of Maryland, College Park, MD, USA
[b] Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, UK

ARTICLE INFO

Keywords:
Calcium
Phosphorus
Digestibility
Age effect
Phytase efficacy

ABSTRACT

A total of 648 straight-run hatchling Heritage 56M × fast feathering Cobb 500F broiler birds were used to determine the effects of Ca concentration and age on phytase efficacy. Corn and SBM based diets with 0.19% non-phytate P were prepared with three Ca (6.5, 8.0 and 9.5 g/kg) concentrations. A 6-phytase[5] was added on-top at 0, 500 or 1000 FTU/kg at each Ca concentration, resulting in a total of 9 treatments. Broiler birds were fed the diets for 2 d either from 7 to 9 (6 birds/replicate) or 19 to 21 (3 birds/replicate) d of age, and ileal content was collected from every bird at the end of each feeding period to determine apparent ileal digestibility coefficient (**AID**). Age effect was determined by comparing responses between birds fed from 7 to 9 and 19 to 21 d of age. There was no interaction between Ca and phytase on AID P regardless of age. Increasing Ca from 6.5 to 9.5 g/kg resulted in 12 (0.58 vs. 0.51) and 11% (0.64 vs. 0.57) reduction in AID P, in 9-d-old and 21-d-old birds, respectively ($P < .05$). Compared to birds fed diets without phytase, AID P was 100 and 155% greater in 9 d old birds fed 500 and 1000 FTU phytase/kg diets, respectively ($P < .05$). Similar but lesser improvement in AID P was also seen in 21 d old birds, with 63 and 76% improvement as a result of 500 and 1000 FTU/kg phytase inclusion, respectively ($P < .05$). Despite similar pattern in response to Ca and phytase, the degree of dietary impact and efficacy of phytase was affected by age of birds. In the absence of phytase, detrimental effect of Ca was more apparent in 9 d old than 21 d old bird, where greater difference in AID P was seen when Ca increased from 6.5 to 9.5 g/kg. With phytase inclusion, differences in AID P between 9 and 21 d old birds were reduced, which was more apparent with higher phytase and Ca inclusion. Net improvement of digestible P for 500 and 1000 FTU phytase/kg was 1.55 and 2.42, 1.45 and 1.72 g/kg, respectively for 9 and 21 d old birds. It is clearly shown that, even though birds at different ages responded to Ca and phytase similarly, the detrimental impact of Ca and benefit of phytase inclusion was greater in younger than older birds.

* Corresponding author.
E-mail addresses: wenting.li@dupont.com (W. Li), rangel@umd.edu (R. Angel).
[1] Current address: Danisco Animal Science, DuPont Industrial Biosciences, Marlborough, SN8 1XN, UK.
[2] Current address: Cargill S.L.U Cargill Animal Nutrition., Mequinenza, Zaragoza, Spain.
[3] Current address: Animal Biosciences and Biotechnology Laboratory, USDA, ARS, Beltsville, MD 20705, USA.
[4] Current address: Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria, 0028, South Africa.
[5] Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, UK

https://doi.org/10.1016/j.anifeedsci.2018.01.021
Received 22 August 2017; Received in revised form 25 January 2018; Accepted 29 January 2018
0377-8401/

1. Introduction

Phosphorus (**P**) is usually the third most expensive nutrient in poultry feed following protein and energy (Potchanakorn and Potter, 1987; AgriStats 2012 end of year summary, 2013). Even though 40–60% of P presented in typical corn-soybean meal (**SBM**) based poultry diets is in the form of phytate-P (**PP**) (National Research Council, 1994), the availability of PP varies and can be affected by several factors (Applegate et al., 2003). For example, Tamim et al. (2004) showed that PP disappearance was 69.2% in birds fed a corn-soybean meal based diet without added inorganic Ca or P, whereas adding 5 g/kg of inorganic Ca from limestone decreased PP disappearance to 25.4%. Similar negative impact of dietary Ca has also been demonstrated in several other studies (Tamim and Angel, 2003; Rousseau et al., 2012; Adeola and Walk, 2013). In contrast to the negative effect of Ca, it has been well demonstrated in poultry species that utilization of PP can be significantly improved by phytase (Angel et al., 2002; Selle and Ravindran, 2007; Adeola and Cowieson, 2011).

Despite the known effects of Ca and phytase on PP utilization, the interaction between the two factors is not clear, as both neutral and negative impacts of Ca on phytase efficacy have been reported (Tamim et al., 2004, Manangi and Coon, 2008, Rousseau et al., 2012; Adeola and Walk, 2013). In part, these discrepancies can be due to different ranges of Ca tested, differences in the physical characteristics and solubility of the limestones used, as well as the specific activity and/or concentration of the phytase tested.

To date, most digestibility studies especially those related to phytase are done in 3-wk-old broilers (between 18 and 24 d of age) and rarely are any studies conducted in younger birds (< 14 d of age). Given that the intestinal tract undergoes tremendous changes during the first two weeks post hatch (Obst and Diamond, 1992; Uni et al., 1998; Uni et al., 1999), accompanied by increased digestion and absorption of dietary nutrients, differences in response to diet impact in the presence and absence of phytase are likely to exist between younger and older birds. Thus, the objectives of the current study were to: 1) determine the impact of Ca on the efficacy of a new generation *Buttiauxella* 6-phytase in 9 and 21 d-old broiler birds and 2) determine the impact of age on the responses to diet Ca and phytase on apparent ileal P digestibility.

2. Materials and methods

2.1. Animals and housing

All animal care procedures were approved by the University of Maryland Animal Care and Use Committee.

On day of hatch, 648 straight run Heritage 56M × fast feathering Cobb 500F broiler birds were obtained from a local commercial hatchery and placed in floor pen rooms with artificial light and temperature control. A commercial type starter diet with adequate nutrient concentrations (National Research Council, 1994, AgriStats 2012 end of year summary, 2013) and no exogenous phytase (225 g/kg CP, 13 g/kg digestible Lys, 13.1 MJ/kg ME_n, 10 g/kg Ca, and 4.5 g/kg non-phytate P (**nPP**)) was fed to birds until d 6. In the morning of d 7, birds (average body weight was 147 ± 1, 6 birds/pen) were placed into battery pens (Modified Petersime grower batteries, Petersime Incubator Co, Gettysburg OH) preassigned to treatment (**Trt**) based on a within block (room) randomization. Birds were weighed individually to ensure similar pen weight and to minimize within pen weight variation. The wire floored battery pens (Width × Depth × Height; 99 cm × 68 cm × 37 cm) were equipped with nipple drinkers (2 per pen) and 2 external feed troughs (Length × Width × Depth; 63.5 cm × 8.9 cm × 5.67 cm). The remaining birds were kept in the floor pens and continued to be fed the starter diet until d 19. For the birds placed in battery cages, Trt diets were fed from 7 to 9 d of age. On d 9, all birds in the battery cages were euthanized by cervical dislocation and distal ileal content was collected from all birds for digestibility determination. The distal ileum was defined as the last half of the intestinal portion between Meckel's diverticulum and the ileo cecal junction. The same procedure was applied again on d 19 (average weight was 697 ± 21 g) on the remaining birds kept in floor pens and fed the same starter diet from d 0. At 19 d, 3 birds were placed in each pen. Treatment diets were offered to from 19 to 21 d of age and distal ileal content were collected in the morning of d 21. Pen assignment remained the same between the two feeding periods to avoid potential pen effect.

Photoperiod for both battery cage and floor pen rooms was 24 light **(L)**:0 dark **(D)** from hatch to 3 d, 14L:10D from 4 to 7 d, 16L:8D from 8 to 12 d, and 18L:6D from 13 to 21 d of age. Room temperature was kept at an average of 31 °C from hatch to 3 d and brooder lamps were used to provide additional heat. Temperature was lowered by 1 °C every 2–3 d such that bird comfort was maintained and temperature was 24 °C at 21 d of age. Birds were checked twice daily and weight of dead bird was recorded. Feed and water were offered for *ad libitum* consumption throughout the trial.

2.2. Experimental design and diets

A corn and SBM mash basal diet[6] (mean diameter[7] ($\mathbf{d_{gw}}$) = 0.854 mm; geometric SD ($\mathbf{S_{gw}}$) = 0.576 mm) was mixed and analyzed for dry matter, macro minerals, protein, ether extract, and amino acids (Table 1). Based on the analyzed Ca and P concentrations in

[6] Particle size and distribution for diets, monocalcium phosphate and limestone were determined by ASAE method S319.3, 1997.

[7] Particle size distribution of basal diet: > 2.360 mm, 2.03%; 2.000–2.360 mm, 3.02%; 1.700–2.000 mm, 6.28%; 1.400–1.700 mm, 11.00%; 1.180–1.400 mm, 10.63%; 1.000–1.180 mm, 11.99%; 0.850–1.000 mm, 11.83%; 0.710–0.850 mm, 7.24%; 0.500–0.710 mm, 19.10%; 0.300–0.500 mm, 11.73%; 0.250–0.300 mm, 1.89%; < 0.250 mm, 3.25%.