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Effect of a novel plant phytase on performance, egg quality, apparent ileal nutrient digestibility and bone mineralization of laying hens fed corn–soybean diets

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ABSTRACT

The efficacy of a novel transgenic corn-derived phytase (TCDP) and two other commercial microbial phytases (PA and PB) were compared in the long-term feeding study of laying hens. The treatments consisted of a positive control (PC) diet adequate in phosphorus (P, 0.32% nonphytate P, NPP); a negative control (NC) diet low in P (0.10% NPP); and an NC supplemented diet containing three phytase sources (TCDP, PA or PB) at two supplemental levels (500 or 5000 FTU/kg of diet). Eight diets were fed to Hy-line hens ($n = 576$) from 50 to 66 weeks of age. We found that with a reduction in dietary P in the NC diet, egg production, egg mass, feed intake, final BW, BW gain, eggshell thickness, and eggshell strength of laying hens decreased ($P<0.05$). In addition, the number of soft-shelled, cracked and broken eggs increased ($P<0.05$) in the NC group. The addition of TCDP, PA or PB significantly increased laying production and egg quality ($P<0.05$), and performed similarly in hens fed the PC diet. Hens fed each source of phytase had greater apparent ileal P digestibility, tibia ash, and bone breaking strength than hens fed the NC diet ($P<0.05$). The apparent ileal P digestibility increased as phytase level increased from 500 to 5000 FTU/kg of diet ($P<0.05$). Results from this study indicate that the addition of TCDP to a P-deficient diet improves laying performance, egg quality, ileal P utilization, and bone mineralization, and TCDP is as efficacious as two commercial microbial phytases when P-deficient diets for laying hens were supplemented with it.

1. Introduction

Phytate is the main storage form of phosphorus (P) in plant feedstuffs (Pointillart et al., 1984). However, phytate-bound P is difficult for monogastric animals to digest due to a lack of sufficient phytase activity in their digestive tracts (Simons et al., 1990). As a consequence, inorganic P is added to diet to fulfill animals' P requirements which leads to environmental pollution due to the excretion of partly of dietary P that the animals have not utilized (Foy and Withers, 1995). To reduce the amount of P released into the environment, exogenous microbial phytase supplementation in low-P diets has been considered one of the most effective ways to improve phytate P utilization and to reduce P output (Dilger et al., 2004).

Abbreviations: BW, body weight; Ca, calcium; CC, conventional corn; DM, dry matter; N, nitrogen; NC, negative control; NPP, nonphytate phosphorus; P, phosphorus; PC, positive control; PTC, phytase transgenic corn; TCDP, transgenic corn derived-phytase; Ti, titanium dioxide.

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There are several phytase products currently available, including microbial phytase and plant phytase (Zhang et al., 2000). Recently, an *Aspergillus niger*-derived phytase expressed in the endosperm of corn has been developed (Chen et al., 2008). As an innovative way of delivering phytase to non-ruminants for better utilization of phytate P, phytase transgenic corn (PTC) will allow animal feed producers to eliminate the need to purchase phytase and corn separately and then to mix them together, which will save time, machinery, and labor. Therefore, transgenic corn-derived phytase (TCDP) may have more potential for future development than commercial microbial phytase. However, no research has been conducted to evaluate the efficacy of the novel TCDP when used as a supplement for P-deficient diets.

The hypothesis tested in the present study was that TCDP would be as efficacious as microbial phytase (PA or PB) when added to a P-deficient diet for laying hens in improving laying performance, egg quality, ileal nutrient digestibility, and bone mineralization.

2. Materials and methods

This study was approved by the Animal Care and Use Committee of China Agricultural University.

2.1. Experimental design

The treatments consisted of a positive control (PC) with 0.32% nonphytate P (NPP) and a negative control (NC) with 0.10% NPP plus a 3×2 factorial arrangement with three sources of phytase (TCDP, PA or PB) at two levels (500 or 5000 FTU/kg of diet). Phytase activity in the PTC was 8980 FTU/kg of DM. One phytase activity unit (FTU) is defined as the quantity of enzyme needed to release 1 μmol of inorganic P per minute from 1.5 mM sodium phytate at pH 5.5 at 37 °C.

2.2. Corn and diet

The nutrient and energy content of PTC and of one type of non-transgenic conventional corn (CC) have been reported previously by Gao et al. (2012). For the present experiment all the diets were formulated so as to contain adequate concentrations of all nutrients except P required for laying hens (Table 1) as dictated by the National Research Council (NRC, 1994).

Table 1
Ingredients and chemical composition of the experimental diets (g/kg, as-fed basis).

Item	Diet[a]							
	PC	NC	PA_{500}	PB_{500}	$TCDP_{500}$	PA_{5000}	PB_{5000}	$TCDP_{5000}$
Ingredient								
Corn (non-genetically modified)	624.0	624.0	624.0	624.0	561.6	624.0	624.0	–
Phytase transgenic corn	–	–	–	–	62.4	–	–	624.0
Soybean (non-genetically modified)	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0
Corn oil (non-genetically modified)	12.0	12.0	12.0	12.0	11.5	12.0	12.0	7.0
Limestone	83.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0
Dicalcium phosphate	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salt	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
DL-Methionine	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Choline chloride	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vitamin and trace mineral premix[b]	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Zeolite powder	0.0	7.0	7.0	7.0	7.5	7.0	7.0	12.0
Phytase activity (FTU/kg)[c]	0	0	500	500	500	5000	5000	5000
Nutrient level								
Apparent metabolizable energy (MJ/kg)[c]	11.18	11.18	11.18	11.18	11.18	11.18	11.18	11.18
Crude protein[c]	166.0	166.0	166.0	166.0	166.0	166.0	166.0	166.0
Lysine[d]	7.9	7.8	7.9	7.9	7.6	7.8	7.7	7.7
Methinoine[d]	3.7	3.8	3.6	3.8	3.7	3.7	3.9	3.7
Methinoine + cystine (%)[c]	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
Calcium[d]	35.0	35.0	35.1	35.1	35.2	35.1	35.1	35.1
Total phosphorus[d]	5.7	3.4	3.4	3.3	3.3	3.4	3.2	3.4
Nonphytate phosphorus[d]	3.2	1.0	1.0	1.1	1.0	1.1	1.0	1.2
Phytase activity (FTU/kg)[d]	28	34	512	514	533	5117	5068	5094

[a] PC = positive control; NC = negative control; PA_{500} = commercial phytase source A (Natuphos, BASF AG, Ludwigshafen, Germany) at 500 phytase units (FTU)/kg of diet; PB_{500} = commercial phytase source B (Phyzyme XP, Danisco Animal Nutrition, Carol Stream, IL) at 500 FTU/kg of diet; $TCDP_{500}$ = transgenic corn derived phytase at 500 FTU/kg of diet; PA_{5000} = commercial phytase source A at 5000 FTU/kg of diet; PB_{5000} = commercial phytase source B at 5000 FTU/kg of diet; $TCDP_{5000}$ = transgenic corn derived phytase at 5000 FTU/kg of diet.

[b] Provided per kilogram of diet: vitamin A, 12,200 IU; vitamin D_3, 4125 IU; vitamin E, 30 IU; vitamin K, 4.5 mg; thiamine, 1 mg; riboflavin, 8.5 mg; calcium pantothenate, 50 mg; niacin, 32.5 mg; pyridoxine, 8 mg; biotin, 2 mg; folic acid, 5 mg; vitamin B_{12}, 5 mg; manganese, 80 mg; iodine, 1 mg; iron, 60 mg; copper, 8 mg; zinc, 80 mg; selenium, 0.3 mg.

[c] Calculated values.

[d] Determined values.