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Effect of phytase supplementation on growth performance, nutrient digestibility, and meat quality in broilers

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Abstract

A total of 459 broiler chicks were studied from 1 to 32 days of age to evaluate the effect of phytase diet supplementation on their growth performance, nutrient digestibility, and meat quality. Chicks were randomly divided into 3 treatments (9 replicates/treatment, 17 chicks/replicate). This was a 32 day experiment that included 2 phases: phase 1, grower (0 to 17 day); and phase 2, finisher (17 to 32 day). Dietary treatments were: T1, control basal diet (CON); T2, CON + 0.01% phytase (300 IU); and, T3, CON + 0.01% phytase (500 IU). Results showed that supplementation of the basal diet with phytase increased pH value of meat. During the period between day 7 and 17 of the study, T2 and T3 groups had higher body weight gain (BWG) than T1 group. After phase 2 and the use of finisher feed, T3 group had significantly improved BWG and feed intake (FI). During the whole experiment, T3 resulted in higher BWG and FI than other treatments. But feed conversion ratio was not affected by phytase supplementation throughout the experiment. Both T2 and T3 groups had significantly higher apparent total tract digestibility of dry matter when compared with T1. However, no differences were observed for Nitrogen, Ca, and P during the experiment. In conclusion, supplementation of phytase increased BW, FI, and apparent total tract digestibility (ATTD) of dry matter (DM). However, there was no significant influence in feed conversion ratio (FCR), relative organ weight and breast muscle quality.

Keywords: broiler, growth performance, meat quality, nutrient digestibility, phytase

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Introduction

Phytate is a naturally occurring complex compound, which can form complexes with protein or cations such as Cu^{2+}, Zn^{2+}, Ni^{2+}, Co^{2+}, Mn^{2+}, Fe^{3+}, and Ca^{2+} (Vohra et al., 1965; Morris, 1986). The phosphate present in the phytate is not available for absorption unless it is liberated from the inositol molecule by either intestinal or microbial phytase, or feed with intrinsic phytase activity (Sandberg et al., 1993). According to previous reports, supplemental phytase improves the availability of P and Zn (Simons et al., 1990; Biehl et al., 1995; Denbow et al., 1995; Yi et al., 1996, Hong et al., 2016) as well as the ileal digestibility of crude protein and amino acids, and apparent metabolizable energy in poultry (Ravindran et al., 1999). Minerals have a variety of functional characteristics. The main mineral bases, Ca and P, can support skeletal growth, eggshell formation, and several other physiological functions. In mineral feedstuffs, P is mainly present as a Ca phosphate, whereas in many plant feedstuffs P is largely present in the form of phytate (Zhang et al., 2017). Given the rise in phosphate prices and environmental pollution of phosphorus on surface water, feed producers are looking for alternatives. A partial solution or strategy for poultry producers can be found through “New generation” phytases, limitation of dietary P concentration, and the use of appropriate Ca : P ratios, or a combination of these strategies. Several studies demonstrated the beneficial effects of phytase on phytate phosphate availability (Snow et al., 2004; Manangi et al., 2008; Powell et al., 2011). In other words, phytase releases P from the phytate, making it available for monogastric animals and thus reducing P excretion into the environment. An optimization of P use in poultry production depends on many factors in feed, such as P availability and interactions with phytase (Driver et al., 2005; Narcy et al., 2009; Létourneau-Montminy et al., 2010; Létourneau-Montminy et al., 2012). The objective of the present experiment was to investigate the effect of phytase supplementation on growth performance, nutrient digestibility, and meat quality in broilers.

Material and Methods

The Animal Care and Use Committee of Dankook University, South Korea approved the protocol used for this experimental study.

Experimental design, animals, and housing

A total of 459 broilers were used in a 32 day experiment. Chicks are randomly allotted to 3 experimental diets. Nine replicate pens containing 17 chicks per pen were used. All animals were housed in thermostatically controlled battery brooders with raised wire floors and were exposed to continuous fluorescent light. Feed and water were provided ad libitum throughout the 32 d trial. The experimental design was completely randomized with 3 treatments. The variable was phytase. The feeding program consisted of phase 1, grower feed (days 0 - 17) and phase 2, finisher feed (days 17 - 32). Dietary treatments were T1, control basal diet (CON); T2, CON + 0.01% phytase (300 IU, GenoFocus Inc., Daejeon, Korea); and, T3, CON + 0.01% phytase (500 IU). The ingredients and compositions of the experimental diets are listed in Table 1. The phytase was made from thermostable fungi and had more than 350,000 unit/mL at pH 7.0. Its appearance was a brown to dark brown liquid. Under normal conditions, pH was 5.0 ± 1.0.

Experimental procedures and sampling

The broilers were weighed by cage, and feed intake was recorded on days 0, 17, and 32 to calculate body weight gain (BWG), feed intake (FI), and feed conversion ratio (FCR). To determine apparent total tract digestibility (ATTD) for dry matter (DM), nitrogen (N), Ca, and P, broilers were fed diets mixed with chromic oxide (0.2%) as an indigestible marker from day 26 to 32. At the last day of the experiment, excreta samples were collected from each pen. For meat quality determination, at the

Table 1. Basal diet composition (as-fed basis).

Items	Grower			Finisher		
	T1	T2	T3	T1	T2	T3
Ingredients (%)						
4 mm corn	54.402	55.702	57.972	59.312	60.482	62.152
SBM, 45, Bra	27.57	27.42	25.39	22.74	22.63	21.44
Corn Gluten, DOM			0.53			
Seasame meal, mech, full	2	2	2	1.5	1.5	1.5
DDGS, Corn	3	3	3	3	3	3
Meat meal,	5	5	5	5	5	5
Tallow	4.9	4.2	3.5	5.3	4.7	4.3
Limestone	0.5	0.5	0.5	0.5	0.5	0.5
Monodlcalclum P	1.05	0.59	0.45	1.01	0.55	0.41
Salt	0.23	0.23	0.23	0.23	0.23	0.23
Methionine, 99%, L-form	0.34	0.34	0.33	0.35	0.34	0.34
Lysine, 50%	0.48	0.47	0.52	0.52	0.51	0.54
Threonine, 98.5%	0.14	0.13	0.14	0.15	0.14	0.15
V-2000[y]	0.1	0.1	0.1	0.1	0.1	0.1
Choline, 50%	0.1	0.1	0.1	0.1	0.1	0.1
M-1100[z]	0.1	0.1	0.1	0.1	0.1	0.1
CuSO4	0.038	0.038	0.038	0.038	0.038	0.038
Phytase		0.03	0.05		0.03	0.05
Enzyme	0.05	0.05	0.05	0.05	0.05	0.05
Total (%)	100	100	100	100	100	100
Nutrient level (%)						
Dry matter	87.86	87.70	87.65	87.77	87.70	87.61
Crude protein	21.50	21.51	21.49	19.51	19.49	19.50
Crude fat	7.92	7.27	6.60	8.29	7.71	7.35
Crude fiber	3.26	3.29	3.24	3.13	3.14	3.13
Ash	5.09	4.65	4.93	4.77	4.83	4.64
Metabolizable energy (kcal/kg)	3119	3124	3110	3226	3214	3219
Ca	0.94	0.94	0.94	0.84	0.95	0.92
Total P	0.73	0.64	0.60	0.70	0.61	0.58
Available P	0.44	0.43	0.43	0.42	0.42	0.42
Digestive Lys	1.059	1.058	1.058	1.059	1.058	1.061
Digestive Met	0.623	0.624	0.620	0.608	0.599	0.601
Digestive Cys	0.252	0.253	0.256	0.228	0.228	0.230
Digestive Thr	0.770	0.768	0.768	0.712	0.709	0.712
Digestive Trp	0.195	0.197	0.200	0.170	0.171	0.178

T1, control basal diet (CON); T2, CON + 0.01% phytase (300 IU, GenoFocus Inc., Daejeon, Korea); T3, CON + 0.01% phytase (500 IU).

[y]Provided per kg of diet: 15,000 IU of vitamin A 3,750 IU of vitamin D3, 37.5 mg of vitamin E, 2.55 mg of vitamin K3, 3 mg of B1, 7.5 mg of B2, 4.5 mg of vitamin B6, 24 μg of vitamin B12, 51 mg of niacin, 1.5 mg of folic acid, 126 mg of biotin and 13.5 mg of pantothenic acid.

[z]Provided per kg of complete diet: 37.5 mg of Zn (as $ZnSO_4$), 137.5 mg of Mn (as MnO_2), 37.5 mg of Fe (as $FeSO_4 \cdot 7H_2O$), 0.83 mg of I (as KI), and 0.23 mg of Se (as $Na_2SeO_3 \cdot 5H_2O$) and 1,408 mg of choline.

Broilers were randomly allotted to one of 3 treatments with 9 replicates.

end of the experiment, 9 broilers were randomly selected from each treatment (1 bird per pen), weighed individually, and killed by cervical dislocation. The gizzard, breast meat, bursa of Fabricius, liver, spleen, and abdominal fat were then removed by trained personnel. The organs were stored at - 20℃ for the subsequent meat quality analyses.

Chemical analysis

Before chemical analysis for DM, N, and GE, excreta samples were dried at 57℃ for 72 hours, after which they were ground to pass through a 1 mm screen. All feed and excreta samples were analyzed for DM (method 930.15; AOAC, 2007) and crude protein (method 990.03; AOAC, 2007). Chromium was analyzed via UV absorption spectrophotometry (Shimadzu UV-1201, Shimadzu, Kyoto, Japan). The gross energy (GE) was determined by measuring the heat of combustion in the samples using a Parr 6100 oxygen bomb calorimeter (Parr instrument Co., Moline, IL, USA). The ATTD was calculated using the following formula:

Digestibility (%) = $[1 - \{(Nf \times Cd) / (Nd \times Cf)\}] \times 100$, where Nf = nutrient concentration in excreta (% DM), Nd = nutrient concentration in diet (% DM), Cd = chromium concentration in diet (% DM), and Cf = chromium concentration in excreta (% DM).

To measure the relative organ weight, broiler organs including the gizzard, breast meat, bursa of Fabricius, liver, spleen, and abdominal fat were weighed and expressed as a percentage of body weight in the laboratory. The breast muscle Hunter color values for lightness (L*), redness (a*), and yellowness (b*) values were determined (Minolta CR410 Chroma Meter; Konica Minolta Sensing Inc., Osaka, Japan). Duplicate pH values for each sample were measured using a pH meter (Fisher Scientific, Pittsburgh, PA, USA). Drip loss was measured using approximately 2 g of meat sample according to the plastic bag method described by Honikel (1998).

Statistical analysis

The data were analyzed using the general linear model procedure for analysis of variance (SAS Institute, 1990). Significant differences among treatment means were separated by Duncan's new multiple range test (Duncan and Duncan, 1955) with a 5% level of probability. There were no significant differences between sexes in broiler response and dietary treatments; thus, data of males and females were pooled.

Results

Growth performance

The effects of phytase supplementation on growth performance are shown in Table 2. In phase 1, between days 7 and 17, T2 and T3 groups had higher BWG than T1. In phase 2, after the use of finisher feed, the T3 group had significantly increased BWG and FI. Additionally, broilers under T3 diet had the highest BWG and FI among the treatments.

Nutrient digestibility

The effects of phytase supplementation on nutrient digestibility are shown in Table 3. During the entire experiment, as for DM, both T2 and T3 groups had significant differences when compared with T1. However, no differences were observed on N, Ca, and P during the experiment.

Meat quality and relative organ weights

The effects of phytase supplementation on meat quality and relative organ weight are shown in Table 4. Meat pH values decreased in broilers fed phytase supplementation treatments compared with T1. No effect was detected on breast muscle color, relative weight of liver, spleen, bursa, breast muscle, abdominal fat, and gizzard associated to phytase supplementation.

Table 2. Effect of phytase supplementation on body weight gain, feed intake (FI), and feed conversion ratio (FCR) in broilers.

Items	T1	T2	T3	SE
d 1-7				
BWG (g)	128	129	129	3
FI (g)	158	159	158	5
FCR	1.234	1.233	1.225	0.07
d 7-17				
BWG (g)	484b	496a	499a	4
FI (g)	685	692	691	7
FCR	1.415	1.395	1.385	0.018
d 17-32				
BWG (g)	908b	950ab	971a	16
FI (g)	1324b	1372ab	1383a	15
FCR	1.458	1.444	1.424	0.026
Overall				
BWG (g)	1520b	1575ab	1599a	17
FI (g)	2167b	2223ab	2232a	16
FCR	1.426	1.411	1.398	0.025

T1, control basal diet (CON); T2, CON + 0.01% phytase (300 IU, GenoFocus Inc., Daejeon, Korea); and, T3, CON + 0.01% phytase (500 IU); SE, Standard error.
a - b: Means in the same row with different superscripts differ ($p < 0.05$).
Broilers were randomly allotted to one of 3 treatments with 9 replicates.

Table 3. Effect of phytase supplementation on the apparent total tract nutrient digestibility in broilers.

Items (%)	T1	T2	T3	SE
Dry matter	72.68b	73.71a	73.76a	0.21
Nitrogen	68.71	69.69	69.89	0.53
Ca	60.73	60.88	60.88	0.64
P	46.44	46.55	46.54	1.36

T1, control basal diet (CON); T2, CON + 0.01% phytase (300 IU, GenoFocus Inc., Daejeon, Korea); and, T3, CON + 0.01% phytase (500 IU); SE, Standard error.
a - b: Means in the same row with different superscripts differ ($p < 0.05$).
Broilers were randomly allotted to one of 3 treatments with 9 replicates.

Table 4. Effect of phytase supplementation on meat quality and relative organ weight in broilers.

Items	T1	T2	T3	SE
pH value	6.48a	5.80b	5.74b	0.135
Breast muscle color				
Lightness (L*)	46.81	47.27	49.13	0.828
Redness (a*)	10.13	11.35	10.29	0.652
Yellowness (b*)	8.68	8.46	8.41	0.668
Relative organ weight (%)				
Muscle	13.74	11.66	15.1	0.984
Liver	2.62	2.31	2.83	0.205
Bursa	0.21	0.18	0.15	0.022
Fat	0.8	0.9	0.94	0.136
Spleen	0.09	0.08	0.13	0.021
Gizzard	1.42	1.18	1.43	0.130
Drip loss (%)				
d 1	2.38	1.73	3.20	0.586
d 3	6.53	6.00	7.09	0.870
d 5	9.20	10.79	8.29	1.890

T1, control basal diet (CON); T2, CON + 0.01% phytase (300 IU, GenoFocus Inc., Daejeon, Korea); and, T3, CON + 0.01% phytase (500 IU); SE, Standard error.
a - b: Means in the same row with different superscripts differ ($p < 0.05$).
Broilers were randomly allotted to one of 3 treatments with 9 replicates.

Discussion

The results of the present study show the effect of phytase supplementation on growth performance, nutrient digestibility, and meat quality in broilers. Recent studies about the effect of phytase supplementation in broilers have mostly been researched with a single level of phytase or Ca : P ratio (Simons et al., 1990; Broz et al., 1994). The results of the current study clearly confirmed, and allowed us to evaluate, the effects of different levels of phytase supplementation.

Growth performance

Many researchers have previously demonstrated the beneficial effects of phytase on growth performance in broilers (Sebastian et al., 1996; Qian et al., 1997; Leytem et al., 2008; Delezie et al., 2015). Our results showed that between days 7 and 17 of phase 1, the phytase supplemented groups T2 and T3 had higher BWG than the control group T1. After the use of finisher feed in phase 2, the T3 group had a significant increase in BWG and FI. This means that phytase supplementation has an appreciable effect on growth performance, and that a higher level (500 IU compared to 300 IU) of phytase has a marked impact in broilers. There was no significant difference in FCR among three treatments. This result is in agreement with the results obtained in other studies (Simons et al., 1990; Qian et al., 1996), and shows that a high level of phytase has beneficial effects in broilers.

Nutrient digestibility

As shown in Table 3, in our study, the ATTD of DM was higher with the supplementation of phytase than with the control basal diet. There was no significant difference in the ATTD of N, Ca, and P in the experiment. In general, phytase supplementation had significant effects of DM digestibility. Because there are currently not enough studies related to the effects of phytase on N, Ca, and P digestibility, it is difficult to explain the beneficial effect of phytase on DM digestibility. Therefore, more experiments are needed to explain these results.

Meat quality and relative organ weights

As for meat quality and relative organ weights, meat pH value, breast muscle color, and drip loss are the factors considered when evaluating meat quality (Fletcher, 1999). Only meat pH value had significant difference in the present study. Meat pH value was decreased in broilers fed phytase supplementation treatments compared with those fed control diet. Many researchers have already done the experiments about the effect of phytase supplementation in broilers over the years (Attia, 2003; Han et al., 2009). In consistent with these results, the results of our experiment showed that there was no effect of dietary phytase supplementation on breast muscle color, drip loss and the relative weight of liver, spleen, bursa, breast muscle, abdominal fat, and gizzard. Hence, we were able to conclude that phytase supplementation has little effect on meat quality in broilers.

Conclusion

As our data show, supplementation of phytase increased BW, FI, and ATTD of DM. However, there was no significant influence in FCR, relative organ weight and breast muscle quality.

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