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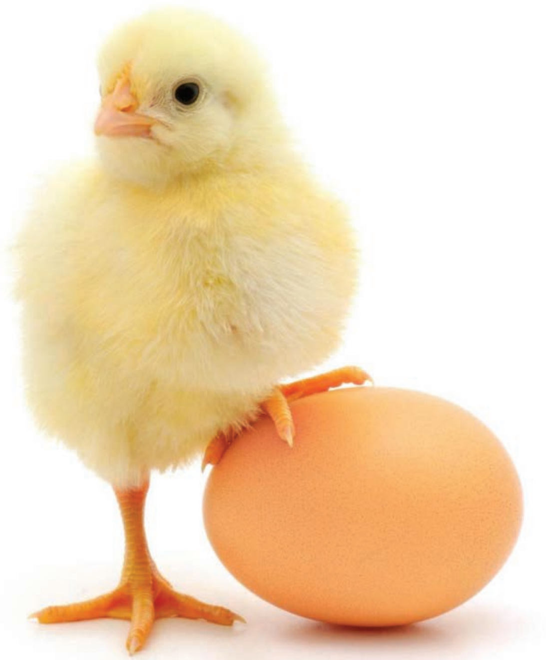

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Research Article
Comparing the Efficacy of Varieties, Low and High Phytase-expressing Corn, at Equivalent Phytase Levels on Broiler Performance and Bone Ash

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Abstract
Objective: A study was conducted to compare the efficacy of two varieties of corn-expressed phytase [low specific activity (203) and high specific activity (1203)] at equivalent FTU kg^{-1} in broilers. **Materials and Methods:** Day-old Cobb 500 male broiler chicks were randomly allocated to one of 10 dietary treatments: Positive Control (PC, standard Ca and aP); Negative Control (NC, -0.15% Ca and aP), NC +0.5 kg MT^{-1} 203, NC+1.0 kg MT^{-1} 203, NC +2.0 kg MT^{-1} 203, NC +3.0 kg MT^{-1} 203, T7, NC+0.18 kg MT^{-1} 1203, NC+0.36 kg MT^{-1} 1203, NC+0.72 kg MT^{-1} 1203, NC +1.08 kg MT^{-1} 1203. All birds were weighed on day 14, 28 and 42 to obtain performance parameters: Body weight (BW), feed consumption (FC) and feed conversion ratio (FCR). On d28, left tibias were sampled from 3 birds per pen, for a total of 30 birds per treatment to determine tibia bone ash. **Results:** On day 14 and d28, birds fed diet supplemented with 203 (day 14, 0.50$\pm$0.00 kg, day 28, 1.80$\pm$0.00 kg) and 1203 (day 14, 0.50$\pm$0.01 kg, day 28, 1.81$\pm$0.01 kg) were heavier ($p\leq0.05$) than PC (day 14, 0.41$\pm$0.00 kg, day 28, 1.65$\pm$0.03 kg) and NC (day 14, 0.41$\pm$0.00 kg, day 28, 1.50$\pm$0.03 kg). On day 42, birds fed diet supplemented with 203 (3.41$\pm$0.04 kg) and 1203 (3.45$\pm$0.03 kg) were heavier ($p\leq0.05$) than NC (3.09$\pm$0.07 kg). On day 0-28 and day 0-42, birds fed diet supplemented with 203 (day 0-28, 1.41$\pm$0.00, day 0-42, 1.61$\pm$0.01) and 1203 (day 0-28, 1.41$\pm$0.00, day 0-42, 1.59$\pm$0.01) improved FCR ($p\leq0.05$) compared to NC (day 0-28, 1.52$\pm$0.01, day 0-42, 1.67$\pm$0.01). On day 28, birds fed diet supplemented with 203 and 1203 (51.69$\pm$0.08%) improved bone ash ($p\leq0.05$) when compared to NC (47.95$\pm$0.95%). **Conclusion:** Both low specific activity and high specific activity corn-expressed phytase varieties improved BW, FCR and bone ash compared to PC. Inclusion of either phytase improved broiler performance and bone mineralization in Ca and aP reduced diets and there were no discernible differences in the efficacy of these two enzymes at the tested loading rates.

Key words: Broiler, corn expressed enzyme, phytase, poultry diet, production

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Broiler diets typically based on cereals and oil seeds in which 70-80% of the phosphorus content is bound in the form of phytate[1,2]. In this form, The availability of phosphorus to poultry and other non-ruminant species is limited, except in diets low in calcium[3]. For this reason, diets are commonly supplemented with inorganic phosphates to mitigate the limited supply of phosphorus from plant ingredients; as a result, feed costs increase along with excretion of phosphorus (P)[4,5]. Phytase enzymes, developed from fungal and microbial sources, are now added to poultry diets to reduce these effects and to reduce the excretion of unwanted P into the environment[6]. By adding this type of enzyme, phytate-bound P can be released and P excretion can be reduced. Feed conversion and growth are also improved by the addition of phytase to poultry diets. Smith *et al.*[7] observed that birds fed phytase at 3,000 FTU kg^{-1} had a lower FCR when compared to those that were fed the standard diet at 500 FTU kg^{-1}. Additionally, birds fed 3,000 and 1,500 FTU kg^{-1} of phytase had higher body weights than those fed the standard diet 500 FTU kg^{-1}.

In poultry diets, microbial phytase is the most common supplement. Making microbial phytase requires fermentation, which is more expensive. As an alternative to microbial phytase, corn expressed phytase (CEP) can lower feed costs. Heat is not required for post harvesting corn expressed phytase which preserves phytase activity and makes corn an ideal crop for expressing phytase.

The novel corn-expressed phytase (CEP; Grainzyme, Agrivida Inc.) contains an engineered *Escherichia coli* phytase called Phy02 and is safe and effective in poultry diets[8,9]. Since CEP is a new form of phytase, so its effects on inorganic phosphate needs further investigation. It is thought that bone mineralization is a more sensitive and prevalent measure of phytase efficacy because phosphorus (P) is a major component of the bird's skeleton[10,11]. In a previous study, Nyannor *et al.*[12] reported that the addition of corn expressed phytase to a P-deficient diet in weanling pigs improved growth performance.

The objective of this experiment was to determine if performance and bone ash response is equivalent between high and low specific activity ("1203" with approx.. 9,000 FTU g^{-1} phytase activity and "203" with approx.. 3,000 FTU g^{-1}) when corn-expressed phytase varieties were fed at equal phytase dose levels. It is thought that corn-expressed phytase varieties (both low and high specific activity) will improve broiler growth performance and bone mineralization in calcium and aP-deficient diets.

MATERIALS AND METHODS

Animal husbandry, diet and experimental design: A total of 2,640 Cobb 500 male broiler chicks were used in this experiment. Day-old broilers were equally housed at 22 birds per replicate pen, pens were blocked in a random complete block design throughout barn. There were 12 replicates per treatment. All pens contained re-used litter as bedding and equipped with one tube feeder and a nipple drinker line. Pens were blocked and treatments were assigned at random to one of ten dietary treatments consisting of positive control or negative control with either high (1203) or low (203) corn-expressed phytase added at different levels (Table 1). The Positive control diet (PC) was formulated for the following calcium and available phosphorus levels:

- Starter: 0.9% Ca and 0.45% aP
- Grower: 0.84% Ca and 0.42% aP
- Finisher: 0.76% Ca and 0.38% aP

The negative control diet (NC) was formulated for the following calcium and available phosphorus levels:

- Starter: 0.75% Ca and 0.30% aP
- Grower: 0.69% Ca and 0.27% aP
- Finisher: 0.61% Ca and 0.23% aP

Both PC and NC diets were corn/soybean-based diets and were formulated based on the Cobb guide. The birds were fed a three-phase diet consisting of a starter (day 1-14, crumble), grower (day 15-28, pellet) and finisher (day 29-42, pellet). Pelleting temperatures were kept at 85°C. Birds were allowed *ad libitum* access to feed and water. Bird management was in accordance with guidelines outlined in the Guide for the Care and Use of Agricultural Animals in Research and Teaching[13], all procedures were approved by Texas A&M University animal care and use committee.

Table 1: Experimental diets fed with positive control or Negative control with low (203) or high (1203) corn expressed phytase

Treatment	Abbreviation	FTU kg^{-1}	FTU level
Positive control	PC	-	-
Negative control	NC	-	-
NC+0.5 kg t^{-1} 203	0.5 kg 203	750	Low
NC+1.0 kg t^{-1} 203	1.0 kg 203	1500	MLow
NC+2.0 kg t^{-1} 203	2.0 kg 203	3000	MHigh
NC+3.0 kg t^{-1} 203	3.0 kg 203	4500	High
NC+0.175 kg t^{-1} 203	0.175 kg 1203	750	Low
NC+0.355 kg t^{-1} 1203	0.355 kg 1203	1500	MLow
NC+0.705 kg t^{-1} 1203	0.705 kg 1203	3000	MHigh
NC+1.06 kg t^{-1} 1203	1.06 kg 1203	4500	High

Mlow: Medium low, MHigh: Medium high

Performance and sampling parameters: Mortalities were collected, recorded and weighed each day. All birds and feed were weighed on day 14, 28 and 42 for the determination of body weight gain (BWG), feed intake (FI) and the calculation of mortality adjusted feed conversion ratio (FCR). On day 28, five birds per replicate were euthanized, with left tibias removed for the determination of bone ash. All connective tissues, muscles and fibulas were removed from each collected tibia before analysis. Left tibias were dried in a Forced Air Oven (VWR 89511-410, Radnor, PA) for 12 hrs at 100°C. The dried tibias were then defatted in diethyl ether for 6-8 hrs and allowed to dry under a chemical hood for 12 hrs upon the completion of defatting procedures so all ether could evaporate from the bones. Defatted tibias were dried again at 100°C for 12 hrs, then ashed at 600°C in ceramic crucibles for 24 hrs. All crucibles and tibias were weighed before and after ashing to determine tibia mineral content.

Statistical analysis: All data were analyzed via One-Way ANOVA using the GLM model procedure (Minitab Software) Differences between treatment means were considered significant if P value was less than 0.05. Treatment means that were determined to be significant were further separated using Fishers LSD Test. Analysis was done on all treatments, combined 203 and 1203 treatments and FTU kg^{-1} level.

RESULTS

Body weights: Tables 2-4 show the treatment means for body weights. The 203 and 1203 birds did not differ in body weight at any age (p>0.05); however, they did differ from the PC and NC (Table 3). At day 14, the weight of the PC and NC was the same (p>0.05) while weight of the 203 and 1203 birds was more than the PC and NC. Weight of the PC, 203 and 1203 birds was more (1.6, 1.8 and 1.8 kg, respectively) than the NC birds on day 28 (1.5 kg, p<0.05). At day 42, the weight of the 203 (3.4 kg) and 1203 birds (3.4 kg) was higher (p>0. 05) than the NC birds (3.1 kg) while the weight of the PC birds was intermediate (3.3 kg). Phytase level also affected body weights at all ages (p<0.05) (Table 4). The weight of the PC and NC was lower (p<0.05) than those of the birds fed diet supplemented with phytase at day 14 and 28. At day 42, the weight of the NC was lower (p<0.05) than those of all phytase groups while the weight of the PC was intermediate. In addition, treatment groups that received phytase supplementation differed in body weight, the birds that received the highest dose (4,500 FTU kg^{-1}) showed the highest weight, the birds that received the lowest dose (750 FTU kg^{-1}) showed the lowest weight and the weight of the other two groups were intermediate.

Table 2: Average bird weight (kg) at day 14, 28 and 42 of broilers fed low (203) and high (1203) corn expressed phytase at different levels

Treatments	D14 BW	D28 BW	D42 BW
PC	0.410^{d}	1.646^{d}	3.280^{cd}
NC	0.410^{d}	1.499^{e}	3.087^{d}
0.5 kg 203	0.482^{c}	1.740^{c}	3.310^{bc}
1.0 kg 203	0.505^{b}	1.818^{ab}	3.486^{ab}
2.0 kg 203	0.504^{b}	1.826^{ab}	3.411^{abc}
3.0 kg 203	0.508^{ab}	1.813^{b}	3.449^{abc}
0.175 kg 1203	0.498^{bc}	1.761^{c}	3.358^{abc}
0.355 kg 1203	0.493^{bc}	1.778^{bc}	3.436^{abc}
0.705 kg 1203	0.522^{ab}	1.812^{b}	3.452^{abc}
1.06 kg 1203	0.502^{b}	1.867^{a}	3.544^{a}
SEM	0.004	0.011	0.024
p-value	0.000	0.000	0.001

$^{a-d}$Means within columns with different superscripts differ significantly at p<0.05

Table 3: Average bird weight (kg) at day 14, 28 and 42 of broilers fed low (203) and high (1203) corn expressed phytase

Treatments	D14 BW	D28 BW	D42 BW
PC	0.410^{b}	1.646^{b}	3.280^{bc}
NC	0.410^{b}	1.499^{c}	3.087^{c}
203	0.500^{a}	1.799^{a}	3.414^{ab}
1203	0.504^{a}	1.805^{a}	3.448^{a}
SEM	0.004	0.011	0.024
p-value	0.000	0.000	0.000

$^{a-c}$Means within columns with different superscripts differ significantly at p<0.05

Table 4: Average bird weight (kg) at d 14, 28 and 42 of broilers fed differing FTU levels

Treatments	D14 BW	D28 BW	D42 BW
PC	0.410^{d}	1.646^{d}	3.280^{cd}
NC	0.410^{d}	1.499^{e}	3.087^{d}
Low	0.490^{c}	1.751^{c}	3.334^{bc}
MLow	0.499^{bc}	1.798^{b}	3.461^{ab}
MHigh	0.513^{a}	1.819^{ab}	3.432^{abc}
High	0.505^{ab}	1.840^{a}	3.497^{a}
SEM	0.004	0.011	0.024
p-value	0.000	0.000	0.000

$^{a-e}$Means within columns with different superscripts differ significantly at p<0.05, MLow: Medium low, MHigh: Medium high

Feed consumption: Tables 5-7 show the feed consumption. From day 0-42, feed consumption was not different between the 203 and the 1203 birds (p>0.05) (Table 5), however; they were different from the NC and PC. The 203 and 1203 birds consumed more feed than the PC and the NC during the starter and grower phases (p<0.05) (Table 6). During the finisher phase, feed consumption was not different, however, overall birds treated with phytase consumed more feed than the NC and PC (Table 7). Overall, there was no effect of phytase level as birds treated with phytase consumed similar amounts of feed.

Table 5: Average feed consumption (g bird^{-1} day^{-1}) at day 14, 28 and 42 of broilers fed low (203) and high (1203) corn expressed phytase at different levels

Treatments	D0-14 FC	D14-28 FC	D0-28 FC	D28-42 FC	D0-42 FC
PC	33.5^{e}	128.9^{e}	78.4^{d}	212.300	109.3^{c}
NC	32.2^{e}	124.4^{f}	75.6^{d}	202.900	103.7^{d}
0.5 kg 203	38.8^{d}	134.7^{bcd}	85.3^{bc}	206.700	114.9^{ab}
1.0 kg 203	41.7^{bc}	137.6^{bc}	86.4^{b}	219.200	117.4^{ab}
2.0 kg 203	41.6^{bc}	138.1^{b}	86.9^{ab}	213.300	116.6^{ab}
3.0 kg 203	42.7^{abc}	137.1^{bc}	87.1^{ab}	213.800	116.1^{ab}
0.175 kg 1203	40.8^{cd}	134.5^{cd}	85.8^{b}	210.200	115.4^{ab}
0.355 kg 1203	40.8^{cd}	131.2^{de}	82.8^{c}	212.900	112.6^{bc}
0.705 kg 1203	44.7^{a}	137.9^{bc}	87.9^{ab}	209.200	116.6^{ab}
1.06 kg 1203	43.5^{ab}	143.9^{a}	89.4^{a}	221.000	119.5^{a}
SEM	0.4	0.6	0.5	1.400	0.7
p-value	0.000	0.0	0.0	0.149	0.0

$^{a-f}$Means within columns with different superscripts differ significantly at p<0.05

Table 6: Feed Consumption (g bird^{-1} day^{-1}) at day 14, 28 and 42 of broilers fed low (203) and high (1203) corn expressed phytase

Treatments	D0-14 FC	D14-28 FC	D0-28 FC	D28-42 FC	D0-42 FC
PC	33.5^{c}	128.9^{b}	78.4^{b}	212.300	109.3^{b}
NC	32.3^{c}	124.4^{c}	75.6^{b}	202.900	103.7^{c}
203	41.2^{b}	136.9^{a}	86.4^{a}	213.200	116.3^{a}
1203	42.4^{a}	136.9^{a}	86.5^{a}	213.300	116.0^{a}
SEM	0.4	0.6	0.5	1.400	0.7
p-value	0.0	0.0	0.0	0.182	0.0

$^{a-c}$Means within columns with different superscripts differ significantly at p<0.05

Table 7: Feed consumption (g bird^{-1} day^{-1}) at day 14, 28 and 42 of broilers fed differing FTU levels

Treatment	D0-14 FC	D14-28 FC	D0-28 FC	D28-42 FC	D0-42 FC
PC	33.5^{c}	128.9^{c}	78.4^{d}	212.300^{abc}	109.3^{b}
NC	32.3^{c}	124.4^{d}	75.6^{d}	202.900^{c}	103.7^{c}
Low	39.8^{b}	134.6^{b}	85.5^{bc}	208.400^{bc}	115.2^{a}
MLow	41.2^{b}	134.4^{b}	84.6^{c}	216.000^{ab}	115.0^{a}
MHigh	43.1^{a}	138.0^{a}	87.5^{ab}	211.300^{abc}	116.6^{a}
High	43.1^{a}	140.5^{a}	88.3^{ab}	217.400^{a}	117.8^{a}
SEM	0.40	0.600	0.50	1.400	0.700
p-value	0.00	0.000	0.00	0.069	0.000

$^{a-d}$Means within columns with different superscripts differ significantly at p<0.05, MLow: Medium low, MHigh: Medium high

Feed conversion: Tables 8-10 show the means for mortality adjusted FCR. There were no differences in the starter or finisher phase (p>0.05). However, during the grower phase, all treatments outperformed the NC which resulted in all diets outperforming the NC by d28. At all activity levels of phytase, the NC was outperformed (p<0.05). Overall, from day 0-42, all diets outperformed the NC and performed similarly to the PC (p<0.05) (Table 8). The 203 and 1203 groups (Table 9) and all phytase levels (Table 10) outperformed the NC from day 0-42 and performed similarly to the PC.

Bone ash: The means of tibia bone ash weight and percentage are shown in Tables 11-13. Treatments that were supplemented with 1203 and 203 except for 0.5 kg (203) and 0.175 kg (1203), increased tibia ash content back to PC levels (p>0.05). Overall, 203 and 1203 improved tibia ash to the levels seen with the PC (Table 12). Only the Low phytase treatment (750 FTU kg^{-1}) did not reach PC tibia ash level, however, the Low phytase treatment still had greater (p<0.05) tibia ash than the NC (Table 13).

Table 8: Feed conversion ratio (FCR) at day 14, 28 and 42 of broilers fed low (203) and high (1203) corn expressed phytase at different levels

Treatments	D0-14 FCR	D14-28 FCR	D0-28 FCR	D28-42 FCR	D0-42 FCR
PC	1.245	1.482^{bcd}	1.426^{bc}	1.887	1.615^{b}
NC	1.193	1.633^{a}	1.517^{a}	1.850	1.668^{a}
0.5 kg 203	1.200	1.509^{bcd}	1.428^{bc}	1.882	1.619^{b}
1.0 kg 203	1.215	1.478^{bcd}	1.408^{bcd}	1.904	1.605^{bc}
2.0 kg 203	1.215	1.468^{cd}	1.401^{cd}	1.903	1.611^{bc}
3.0 kg 203	1.230	1.480^{bcd}	1.413^{bc}	1.861	1.601^{bc}
0.175 kg 1203	1.237	1.492^{bc}	1.420^{bc}	1.872	1.611^{bc}
0.355 kg 1203	1.226	1.442^{d}	1.384^{d}	1.809	1.569^{c}
0.705 kg 1203	1.248	1.475^{bcd}	1.413^{bc}	1.811	1.582^{bc}
1.06 kg 1203	1.258	1.490^{bc}	1.429^{b}	1.858	1.614^{b}
SEM	0.005	0.006	0.004	0.019	0.005
p-value	0.068	0.000	0.000	0.978	0.010

$^{a-d}$Means within columns with different superscripts differ significantly at p<0.05

Table 9: Feed conversion ratio (FCR) at day 14, 28 and 42 of broilers fed low (203) and high (1203) corn expressed phytase

Treatments	D0-14 FCR	D14-28 FCR	D0-28 FCR	D28-42 FCR	D0-42 FCR
PC	1.245^{ab}	1.482^{b}	1.426^{b}	1.887	1.615^{b}
NC	1.193^{c}	1.633^{a}	1.517^{a}	1.850	1.668^{a}
203	1.215^{bc}	1.484^{b}	1.412^{b}	1.888	1.609^{b}
1203	1.242^{a}	1.475^{b}	1.412^{b}	1.837	1.594^{b}
SEM	0.005	0.006	0.004	0.019	0.005
p-value	0.007	0.000	0.000	0.679	0.001

$^{a-c}$Means within columns with different superscripts differ significantly at P<0.05

Table 10: Feed conversion ratio (FCR) at day 14, 28 and 42 of broilers fed differing FTU levels

Treatments	D0-14 FCR	D14-28 FCR	D0-28 FCR	D28-42 FCR	D0-42 FCR
PC	1.245	1.482^{bc}	1.426^{b}	1.887	1.615^{b}
NC	1.193	1.633^{a}	1.517^{a}	1.850	1.668^{a}
Low	1.218	1.500^{b}	1.424^{b}	1.877	1.615^{b}
MLow	1.221	1.460^{c}	1.396^{c}	1.857	1.587^{b}
MHigh	1.232	1.472^{bc}	1.407^{bc}	1.857	1.597^{b}
High	1.244	1.485^{bc}	1.421^{b}	1.859	1.607^{b}
SEM	0.005	0.006	0.004	0.019	0.005
p-value	0.103	0.000	0.000	0.997	0.004

$^{a-c}$Means within columns with different superscripts differ significantly at p<0.05, MLow: Medium low, MHigh: Medium high

Table 11: Tibia bone ash (%) at d28 of broilers fed low (203) and high (1203) corn expressed phytase at different levels

Treatments	D28 ASH
PC	52.3^{a}
NC	47.9^{d}
0.5 kg 203	51.2^{bc}
1.0 kg 203	51.6^{abc}
2.0 kg 203	51.7^{abc}
3.0 kg 203	52.1^{ab}
0.175 kg 1203	51.0^{c}
0.355 kg 1203	51.6^{abc}
0.705 kg 1203	51.5^{abc}
1.06 kg 1203	51.8^{abc}
SEM	0.2
p-value	0.0

$^{a-d}$Means within columns with different superscripts differ significantly at p<0.05

Table 12: Tibia bone ash (%) at d28 of broilers fed low (203) and high (1203) corn expressed phytase

Treatments	D28 ASH
PC	52.3[a]
NC	47.9[b]
203	51.6[a]
1203	51.5[a]
SEM	0.2
p-value	0.0

[a-b]Means within columns with different superscripts differ significantly at p<0.05

Table 13: Tibia bone ash (%) at d28 of broilers fed differing FTU levels

Treatments	D28 ASH
PC	52.3[a]
NC	47.9[c]
Low	51.1[b]
MLow	51.6[ab]
MHigh	51.6[ab]
High	52.0[a]
SEM	0.2
p-value	0.0

[a-c]Means within columns with different superscripts differ significantly at p<0.05, MLow: Medium low, MHigh: Medium high

DISCUSSION

Traditional broiler diets consist of grains and cereal in which phosphorus is bound in the form of phytate[1,2]. In this form, the availability of phosphorus to broilers is poor[3]. As phytase hydrolyzes phytate substrates, phosphorous is released in a free form that can be easily absorbed by animals. As a result animals require less supplemental inorganic phosphorus[14]. Furthermore, in broilers, phytate reduces mineral absorption, increases endogenous losses, making it an anti-nutrient[15]. Other studies have shown that at high inclusion rates, phytase can improve FCR[16]. In this current experiment, a corn based phytase was used in corn-soybean meal-based diets to evaluate the effects of two varieties of corn-expressed phytase [low specific activity (203) and high specific activity (1203)] on broiler performance and bone ash.

Throughout this study, birds fed more than 750 FTU kg^{-1} of phytase had a higher body weight than all other treatments. Similar results were observed by Wang and Kim[17] who found that at higher levels of CEP, treatments outperformed the NC. Wang and Kim[17] also found that body weight gain was less sensitive to the dietary nPP requirement than bone mineralization. Additionally, all dietary treatments that were supplemented with 203 or 1203 showed higher average body weights than the NC and were similar to the PC. Similar results were observed by Nyannor *et al.*[12] who evaluated the growth performance.

In the current study, the FCR was lower in all CEP treatments than that of the NC during the first 28 days, which resulted in an overall (day 0-42) better FCR. All CEP levels performed similarly to the PC in making up for the deficiency of the NC diet. During the starter phase (day 0-14), though, there was no apparent difference in FCR, which is similar to the results seen by Wang and Kim[17] who did not see improvements in FCR at any FTU level or inclusion rate of CEP during an 18-day trial. The results of the current study indicate that CEP could be used to maintain FCR similar to a non-deficient diet or even improve FCR. Researchers have observed similar results when testing phytases produced by microbes. However, CEP could be a less expensive way to provide chickens with phytase.

The tibia ash content of 203 and 1203 increased compared to NC on day 28. The FTU level did not affect tibial ash as all levels of phytase had similar ash percent. Findings of Wang and Kim[17] align with this result who found that the addition of CEP increased ash weight and percentage. Similar results were reported by Nelson and Walker[18] who found that tibia ash can be an accurate way to measure P bioavailability demonstrating that the CEP allowed the birds to utilize the phytate found in the NC diet. To that end, Nelson and Walker[18] found that the supplementation of phytase improved tibia ash percentage and noted linear and quadratic responses. Broomhead *et al.*[19], found that when 4,000 FTUs kg^{-1} CEP were added to a PC diet, growth performance and bone ash weight improved. Additionally, Alfonso *et al.*[9], found that when CEP was added to a Ca and P deficient diet, growth performance was improved.

CONCLUSION

The reduction in dietary Ca and aP negatively affected broiler growth performance. Corn-expressed phytase [high specific activity (1203) and low (203) specific activity] improved body weight, feed conversion ratio and bone ash when compared to the NC illustrating that its effectiveness is similar to microbial produced phytase. It also demonstrated that either at high or low activity level, CEP can be used to improve broiler growth, FCR and P utilization in a diet deficient in Ca and P. The addition of CEP improved growth performance and bone mineralization of broilers. To enhance growth and bone health, Phytase can be used more efficiently in poultry feed using CEP technology, which can save time and can also reduce the cost of phytase.

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