



Revista Brasileira de Ciência Avícola

ISSN: 1516-635X

revista@facta.org.br

Fundação APINCO de Ciência e Tecnologia
Avícolas
Brasil

Assuena, V; Junqueira, OM; Duarte, KF; Laurentiz, AC; Filardi, RS; Sgavioli, S
Effect of dietary phytase supplementation on the performance, bone densitometry, and phosphorus and
nitrogen excretion of broilers

Revista Brasileira de Ciência Avícola, vol. 11, núm. 1, enero-marzo, 2009, pp. 25-30

Fundação APINCO de Ciência e Tecnologia Avícolas
Campinas, SP, Brasil

Available in: <http://www.redalyc.org/articulo.oa?id=179713997005>

- How to cite
- Complete issue
- More information about this article
- Journal's homepage in redalyc.org

redalyc.org

Scientific Information System
Network of Scientific Journals from Latin America, the Caribbean, Spain and Portugal
Non-profit academic project, developed under the open access initiative



Effect of Dietary Phytase Supplementation on the Performance, Bone Densitometry, and Phosphorus and Nitrogen Excretion of Broilers

■ Author(s)

Assuena V¹
Junqueira OM²
Duarte KF¹
Laurentiz AC³
Filardi RS³
Sgavioli S¹

- ¹ Dept of Animal Science, Universidade Estadual Paulista Júlio de Mesquita Filho, Faculdade de Ciências Agrárias e Veterinárias de Jaboticabal - UNESP.
- ² Dept of Animal Science, Universidade Estadual Paulista Júlio de Mesquita Filho, Faculdade de Ciências Agrárias e Veterinárias de Jaboticabal - UNESP.
- ³ Dept of Biology and Animal Science, Universidade Estadual Paulista Júlio de Mesquita Filho, Faculdade de Engenharia de Ilha Solteira - UNESP.

■ Mail Address

Vinícius Assuena
Rua Eduardo Padovani, 62 - Vila Melo
13.670-000. Santa Rita do Passa Quatro, SP,
Brasil.

E-mail: viniciusassuena@yahoo.com.br

■ Keywords

Bone mineralization, feed conversion ratio, feed intake, weight gain.

■ Acknowledgements

The authors thank FAPESP for funding this study, under process n. 2005/56681-0.

Arrived: September/2008
Approved: February/2009

ABSTRACT

This experiment was carried out to evaluate the effects of the inclusion of different levels of phytase on broiler performance, bone densitometry, and phosphorus and nitrogen excretion. Nine hundred and sixty one-day old broilers, 50% males and 50% females, were distributed in a completely randomized experimental design into five treatments and six replicates 32 birds each. The treatments consisted of a control diet and four diets with the addition 25, 50, 75, and 100 g/ton of phytase (250, 500, 750 and 1000 FTU of phytase/kg feed). Diets were formulated to contain equal nutritional levels, and considered the phytase product nutritional levels. In general, the addition of phytase resulted in a linear decrease in broiler performance. However, the performance results obtained with the level of 250 FTU phytase/kg feed were not different from the control treatment. The best bone density results were observed in the control treatment, with no phytase. The results of this experiment indicate that the nutritional matrix of the phytase product needs to be reviewed when added in levels higher 250 FTU/kg to broiler diets.

INTRODUCTION

Aiming at lowering production costs, many current research studies have focused on improving the efficiency of feedstuff utilization and to reduce the impact of animal production on the environment (Payne *et al.*, 2005).

Phosphorus is one of the most expensive nutrient of poultry and swine feeds, second only to energy and protein (Borges, 1997). It is nutritionally essential, as shown by its several roles in the body, and it is particularly important during growth. However, two thirds of the phosphorus contained in cereal grains and oil seeds are in the form of phytate, which can bind to other nutrients, rendering them unavailable for poultry and pigs, thereby, requiring dietary inorganic phosphorus supplementation (Denbow *et al.*, 1995).

The production of industrial phytase is based on microorganisms, using DNA recombination techniques. This enzyme increases phosphorus (P) availability in plant feed ingredients, where P is usually present as phytate. The dietary supplementation of phytase allows poultry and pigs to more efficiently absorb phosphorus, reducing the amount of inorganic phosphorus supplementation, and promoting better weight gain, feed conversion ratio, feed intake, and bone mineralization, as well as reducing mortality (Qian *et al.*, 1996).

Along with calcium, phosphorus has an essential role in bone formation. In the animal, phosphorus comprises about 1% of live weight, and it is carefully considered when feeds and supplements are formulated. About 80% of phosphorus in the animal body is deposited



in bones and teeth. Therefore, the inclusion of phytase in broiler diets may enhance their bone development.

The objectives of the present study were to evaluate the effects of the inclusion of different levels of phytase on broiler performance, bone densitometry, and phosphorus and nitrogen excretion in the litter during the starter (1 to 21 days), grower (22 to 42 days), and total (1 to 42 days) rearing phases.

MATERIAL AND METHODS

A total number of 960 (50% male and 50% female) Ross broilers was reared from 1 to 42 days of age in a conventional broiler house.

The experimental period was divided in three phases: starter (1 to 21 days of age), grower (22 to 42 days of age), and total (1 to 42 days of age) rearing periods.

A completely randomized experimental design was applied, including five treatments with six replicates of

32 birds each. Treatments consisted of a control diet and other four diets formulated with graded levels of the enzyme phytase (250, 500, 750, and 1000 FTU/kg feed). Phytase nutritional matrix was considered in feed formulation; therefore, all experimental diets contained the same nutritional levels as the control diet.

The experimental diets were based on corn and soybean meal, and were formulated according to the nutritional recommendations and ingredient composition described by Rostagno *et al.* (2005). Diet composition and nutritional levels fed during the starter (1 to 21 days of age) and grower (22 to 42 days of age) phases are presented in Tables 1 and 2, respectively.

Table 3 shows the nutritional matrix of the commercial enzyme product Natuphos® 10000 for broilers, as described by the manufacturer for an inclusion of 50g enzyme/ton feed, ensuring 500 FTU/kg feed.

Weight gain, feed intake and feed conversion ratio were determined for each rearing phase. At the end

Table 1 - Percentage composition of the experimental diets of the different rearing phases.

Ingredients (%)	Phytase inclusion levels(FTU/kg)									
	Starter phase					Grower phase				
	Control	250 FTU/kg	500 FTU/kg	750FTU/kg	1000FTU/kg	Control	250 FTU/kg	500 FTU/kg	750FTU/kg	1000FTU/kg
Corn, grain	58.6200	59.8315	61.6810	62.9145	64.2980	66.0820	67.6155	69.1700	70.3145	71.4610
Soybean meal 45%	35.0900	34.6650	34.0220	33.5930	33.0370	24.4200	23.8720	23.3210	23.0890	22.8560
Corn gluten 60%	0.0000	0.0000	0.0000	0.0000	0.0000	3.5000	3.5000	3.5000	3.5000	3.5000
Soybean oil	2.6600	2.0530	1.1410	0.5330	0.0000	2.8400	2.0800	1.3170	0.6590	0.0000
Dicalcium phosphate	2.0300	1.7790	1.3950	1.1380	0.7540	1.8000	1.4870	1.1660	0.8440	0.5220
Limestone	0.7200	0.7840	0.8720	0.9310	1.0180	0.6500	0.7300	0.8030	0.8750	0.9470
Vit+min premix	0.2000	0.2000	0.2000	0.2000	0.2000	0.1000	0.1000	0.1000	0.1000	0.1000
Salt	0.4500	0.4560	0.4560	0.4560	0.4560	0.4300	0.4290	0.4290	0.4290	0.4290
L-lysine	0.0000	0.0000	0.0000	0.0000	0.0000	0.0270	0.0340	0.0410	0.0380	0.0350
DL-methionine	0.2300	0.2290	0.2280	0.2270	0.2270	0.1510	0.1500	0.1480	0.1440	0.1400
Phytase	0.0000	0.0025	0.0050	0.0075	0.0100	0.000	0.0025	0.0050	0.0075	0.0100

- Enrichment per kg feed: 8,000 IU vitamin A, 1,800 IU vitamin D3, 12 mg vitamin E, 2 mg vitamin K3, 1 mg vitamin B1, 4 mg vitamin B2, 1 mg vitamin B6, 10 mcg vitamin B12, 0.40 mg folic acid, 0.04 mg biotin, 28 mg niacin, 11 mg calcium pantothenate, 6 mg Cu, 0.10 mg Co, 1 mg I, 50 mg Fe, 65 mg Mn, 45 mg Zn, 0.21 mg Se, 500 mg choline chloride 50%, 1400 mg methionine, 60 mg coccidiostat, 12 mg antioxidant.

Table 2 - Nutritional composition of the experimental diets of the different rearing phases.

	Starter phase					Grower phase				
	Control	250 FTU/kg	500 FTU/kg	750FTU/kg	1000FTU/kg	Control	250 FTU/kg	500 FTU/kg	750FTU/kg	1000FTU/kg
Metabolizable energy (kcal/kg)	3.050	3.050	3.050	3.050	3.050	3.200	3.200	3.200	3.200	3.200
Crude protein (%)	21.14	21.14	21.14	21.14	21.14	19.00	19.000	19.000	19.000	19.000
Calcium (%)	0.897	0.897	0.897	0.897	0.897	0.785	0.785	0.785	0.785	0.785
Available phosphorus (%)	0.480	0.480	0.480	0.480	0.480	0.430	0.430	0.430	0.430	0.430
Sodium (%)	0.215	0.215	0.215	0.215	0.215	0.200	0.200	0.200	0.200	0.200
Total lysine(%)	1.122	1.122	1.122	1.122	1.122	0.900	0.900	0.900	0.900	0.900
Digestible lysine(%)	1.006	1.006	1.006	1.006	1.006	0.804	0.804	0.804	0.804	0.804
Total methionine (%)	0.555	0.555	0.555	0.555	0.555	0.470	0.470	0.470	0.470	0.470
Digestible methionine (%)	0.529	0.529	0.529	0.529	0.529	0.448	0.448	0.448	0.448	0.448
Total Met + Cys (%)	0.890	0.890	0.890	0.890	0.890	0.790	0.790	0.790	0.790	0.790
Digestible Met + Cys (%)	0.829	0.829	0.829	0.829	0.829	0.739	0.739	0.739	0.739	0.739
Total tryptophan (%)	0.263	0.263	0.263	0.263	0.263	0.209	0.209	0.209	0.209	0.209
Digestible tryptophan (%)	0.237	0.237	0.237	0.237	0.237	0.188	0.188	0.188	0.188	0.188

¹ Natuphos® 10000: commercial brand of the company BASF S/A: Estr. Samuel Aizemberg, 1707 - Bloco C - 2. Andar, São Bernardo do Campo - SP - CEP: 09851-550



of the experimental period (42 days of age) production efficiency index ($PEI = [\text{daily weight gain (g)} \times L (\%)] / (\text{feed conversion ratio} \times 10)$) and livability ($L (\%) = [\text{total number of birds} - (\text{number of dead} + \text{culled birds}) / \text{total number of birds}]$) were calculated.

Table 3 - Nutritional matrix of phytase Natuphos®10000.

Nutrients	Amount
Metabolizable energy (kcal/kg)	1,060,000
Crude protein (%)	4,500
Calcium (%)	2,000
Total phosphorus (%)	2,300
Digestible lysine (%)	240
Digestible methionine (%)	20
Digestible cystine (%)	60
Digestible Met+Cys (%)	80
Digestible tryptophan (%)	60
Digestible threonine (%)	260
Digestible valine (%)	316
Digestible isoleucine (%)	240
Digestible leucine (%)	416
Digestible arginine (%)	274
Digestible phenylalanine (%)	274
Digestible histidine (%)	118

At the end of each experimental phase, ten birds per treatment were sacrificed for the collection of the tibiotarsal bone. After removing soft tissues and ligaments, the bones were radiographed for bone densitometry determination. A penetrometer or 12-degree aluminum scale (alloy 6063, ABNT) was used as densitometry reference in the radiographs.

Densitometry readings were carried out after radiographic images were digitalized in appropriate scanner. Data were stored using the "Image-Pro Plus Media Cybernetics" software program, version 4.1. Readings are expressed in aluminum millimeters (mm Al), according to Louzada (1994).

At 35 days of age, two birds per replicate were transferred to metabolic cages and submitted to a completely randomized experimental design that included the same treatments described above. Total excreta collection method was used. The metabolism essay was carried out during eight days, with three days of adaptation to the experimental diets, and five days of excreta collection.

After collection, excreta was frozen, and subsequently processed according to Silva (1990) to obtain samples for analyses. Phosphorus and nitrogen fecal contents were determined by Fatec S/A laboratory.

The obtained results were submitted to analysis of variance using the General Linear Model (GLM) procedure of SAS software package (SAS, Institute, 2002). When significant effects ($p < 0.05$) were

determined by the analysis of variance, linear and quadratic polynomial regression analyses were carried out, and the test of Tukey at 5% probability was performed when significant linear effects were detected.

RESULTS AND DISCUSSION

Table 4 shows performance parameter means for the phase of 1-21 days of age. There was a linear effect of phytase levels ($p < 0.01$) on weight gain ($y = 720.0847 - 0.0592x$; $R^2 = 98.29$) and feed conversion ratio ($y = 1.4161 + 0.0001x$; $R^2 = 99.32$), indicating that with increasing dietary phytase levels, performance declined, and that an optimal phytase levels were not achieved for these parameters in the present experiment. The test of Tukey at 5% probability showed a negative effect on weight gain of levels of 750 FTU phytase/kg feed or higher. The addition of 1000 FTU de phytase/kg feed resulted in the worst feed conversion ratio. Only feed intake was not affected by phytase inclusion levels ($p > 0.05$).

Table 4 - Mean weight gain (WG), feed intake (FI), and feed conversion ratio (FCR) of 1- to 21-day-old broilers fed different phytase levels.

Performance parameters from 1 to 21 days of age			
Treatments	WG(g) ²	FI(g)	FCR(g/g) ³
Control	718 A	1017	1.417 C
250 FTU/kg	710 A	1026	1.444 BC
500 FTU/kg	688 AB	1005	1.462 BC
750 FTU/kg	676 B	1007	1.490 AB
1000 FTU/kg	661 B	1005	1.521 A
F value ¹	8.46**	0.60ns	11.79**
CV (%)	2.88	2.83	1.96

Means followed by different letters in the same column are significantly different ($p < 0.05$) by the test of Tukey. 1 - ns - not significant ; ** - significant ($p < 0.01$). 2 Linear effect of phytase level: $y = 720.0847 - 0.0592x$; ($R^2 = 98.29$). 3 Linear effect of phytase level: $y = 1.4161 + 0.0001x$; ($R^2 = 99.32$)

The results of the present experiment are not consistent with those obtained by Murata *et al.* (2006), who added 750 and 1000 FTU phytase/kg feed and considered phytase matrix nutritional values, but did not observe any significant effects on broiler performance during the starter phase. However, it must be noted that those authors did not present the composition of the nutritional matrix used in their trial.

Conte *et al.* (2003) worked with the inclusion of 15% rice bran and four phytase levels for starter broilers, and observed that feed intake and live weight increased with enzyme inclusion, whereas feed conversion ratio was not influenced by the studied factors.



Using low available phosphorus levels and phytase inclusion, Persia & Saylor (2006) showed that phytase improved the performance of 8- to 22-day-old broilers, as opposed to Angel *et al.* (2006), who did not find any broiler performance differences during the starter phase when adding phytase to low available phosphorus diets.

Table 5 shows performance parameter means for the phase of 22-42 days of age. The results obtained were similar to those of the starter phase, again with no effect of phytase dietary inclusion levels on feed intake ($p>0.05$). There were linear effects ($p<0.01$) of phytase on weight gain ($y = 1621.2943-0.0869x$; $R^2 = 85.82$) and feed conversion ratio ($y = 2.0330+0.000058x$; $R^2 = 94.54$), with worse results in the evaluated parameters as phytase inclusion levels increased, and an optimal phytase level was again not achieved for these parameters. The test of Tukey at 5% de probability showed a negative effect of phytase dietary inclusion of 500 FTU/kg feed and higher on feed conversion ratio as compared to the control treatment, with the worst result obtained with the inclusion of 1000 FTU phytase/kg feed ($p<0.01$). As to weight gain, negative results were obtained with 750 FTU phytase/kg feed and higher ($p<0.01$).

When studying dietary phytase inclusion and different phosphorus levels in 22- to 42-day-old broilers, Wu *et al.* (2004) and Viveros *et al.* (2002) observed positive weight gain results. However, these data cannot be compared with the results of the present study because the aforementioned trials did not consider the enzyme nutritional matrix when formulating the experimental diets.

Table 5 - Mean weight gain (WG), feed intake (FI), and feed conversion ratio (FCR) of 22- to 42-day-old broilers fed different phytase levels.

Treatments	Performance parameters from 22 to 42 days of age		
	WG(g) ²	FI(g)	FCR(g/g) ³
Control	1637 A	3323	2.030 B
250 FTU/kg	1578 AB	3227	2.045 AB
500 FTU/kg	1573 AB	3252	2.068 AB
750 FTU/kg	1562 B	3255	2.083 AB
1000 FTU/kg	1536 B	3203	2.085 A
F value ¹	4.84**	2.30ns	3.44**
CV (%)	2.62	2.24	1.52

Means followed by different letters in the same column are significantly different ($p<0.05$) by the test of Tukey. 1 - ns - not significant; ** - significant ($p < 0.01$). 2 Linear effect of phytase level: $y = 1621.2943-0.0869x$; ($R^2 = 85.82$). 3 Linear effect of phytase level: $y = 2.0330+0.000058x$; ($R^2 = 94.54$)

Table 6 presents performance and production parameter means for the entire experimental period

(1-42 days of age). Weight gain, feed intake, and feed conversion ratio were significantly influenced ($p<0.01$) by dietary phytase level. The polynomial regression of the analysis of variance showed linear effects on weight gain ($y = 2341.3803-0.1461x$, $R^2 = 96.03$), feed conversion ratio ($y = 1.8433+0.00007x$; $R^2 = 98.69$), and production efficiency index ($y = 292.077-0.0266x$; $R^2 = 85.76$). These results indicate that, when phytase was added to the feeds, weight gain and production efficiency index declined, and feed conversion ratio worsened. An optimal phytase level was not achieved for these parameters. The test of Tukey at 5% probability showed that the different phytase feed inclusion levels tested significantly influenced ($p<0.01$) weight gain, feed conversion ratio, and production efficiency index, and that there was no effect ($p>0.05$) on feed intake or livability. It was also the performance observed with the dietary addition of up to 250 FTU de phytase /kg feed was similar to that of the control treatment.

Table 6 - Mean weight gain (WG), feed intake (FI), feed conversion ratio (FCR), livability (L), and production efficiency index (PEI) of 1- to 42-day-old broilers fed different phytase levels.

Treatments	Performance parameters from 1 to 42 days of age				
	WG(g) ²	FI(g)	FCR(g/g) ³	L(%)	PEI ⁴
Control	2355 A	4340.64	1.843 B	97.43	296 A
250 FTU/kg	2289 AB	4253.42	1.859 AB	96.85	284 AB
500 FTU/kg	2261 BC	4258.11	1.883 AB	95.32	272 B
750 FTU/kg	2239 BC	4262.47	1.904 A	97.43	272 B
1000 FTU/kg	2191 C	4208.42	1.898 A	98.44	268 B
F value ¹	8.64**	1.99ns	5.07**	1.21ns	5.73**
CV (%)	2.17	1.94	1.49	2.63	4.17

Means followed by different letters in the same column are significantly different ($p<0.05$) by the test of Tukey. 1 - ns - not significant ; ** - significant ($p < 0.01$). 2 Linear effect of phytase level: $y = 2341.3803-0.1461x$; ($R^2 = 96.03$). 3 Linear effect of phytase level: $y = 1.8433+0.00007x$; ($R^2 = 98.69$). 4 Linear effect of phytase level: $y = 292.077-0.0266x$; ($R^2 = 85.76$)

When levels higher than 500 FTU phytase /kg feed were added to the feeds, weight gain and production efficiency index were lower as compared to the control treatment. As to feed conversion ratio, the worst results were obtained when 750 and 1000 FTU phytase/kg feed were included.

The results obtained for the total rearing period showing that increasing phytase levels had negative effects on performance parameters are different from literature results (Tejedor *et al.*, 2001; Lan *et al.*, 2002; Wu *et al.*, 2004). However, in literature, phytase nutritional matrix results were not considered in the formulation of the experimental diets, and therefore



only the effects of phytase on the availability of phytic phosphorus and of the other nutrients bound to the phytate molecule were evaluated.

Table 7 shows mean bone density results of 1- to 21-day-old broilers. There was a linear effect ($p < 0.05$) of phytase dietary level on all evaluated bone segments, indicating that bone density decreased as phytase level increased. The inclusion of 250 FTU phytase/kg feed and no phytase supplementation (control treatment) promoted the best results.

Onyango *et al.* (2004) evaluated the inclusion of phytase in feeds based on corn and soybean meal with reduced phosphorus content in starter broilers, and observed that bone density, bone mineral content, bone strength, and ash percentage were positively influenced by dietary phytase supplementation.

Most studies that correlate dietary phytase inclusion with phosphorus availability and bone deposition express their results as bone ash and phosphorus percentage and as bone strength (Banks *et al.*, 2004; Payne *et al.*, 2005; Pérsia & Saylor, 2006 e Martinez *et al.*, 2006), and suggest that the inclusion of phytase in diets with different available phosphorus levels promote higher ash content or tibia strength.

Table 7 - Mean bone density evaluated in 1- to 21-day-old broilers fed different phytase levels.

Treatments	Bone density from 1 to 21 days of age		
	Proximal epiphysis (mm Al) ²	Diaphysis (mm Al) ³	Distal epiphysis (mm Al) ⁴
Control	1.8944 AB	2.3677 A	1.5317 A
250 FTU/kg	1.7356 AB	1.9454 AB	1.2577 B
500 FTU/kg	2.0585 A	2.1144 AB	1.5065 A
750 FTU/kg	1.6042 B	1.8209 B	1.1671 B
1000 FTU/kg	1.6660 AB	1.8298 B	1.1885 B
F value ¹	3.53*	3.42*	2.58*
CV (%)	17.31	19.50	26.01

Means followed by different letters in the same column are significantly different ($p < 0.05$) by the test of Tukey. 1 - ns - not significant ; ** - significant ($p < 0.01$). 2 - Linear effect of phytase level: $y = 1.9127 - 0.00024x$; ($R^2 = 25.40$). 3 - Linear effect of phytase level: $y = 2.2557 - 0.00048x$; ($R^2 = 68.25$). 4 - Linear effect of phytase level: $y = 1.4860 - 0.0003x$; ($R^2 = 48.85$).

Mean bone densities of 22- to 42-day old broilers presented in Table 8 show a quadratic effect ($p < 0.01$) of phytase dietary inclusion on the bone density of the studied segments of the tibiotarsal bone. Proximal epiphysis bone density decreased ($y = 2.2897 - 0.00157x + 0.000001x^2$; $R^2 = 67.92$) up the level of 785 FTU, with a minimum density of 1.673 mm Al, whereas above 785 FTU, this value increased. In the diaphysis ($y = 2.1621 - 0.00195x + 0.000002x^2$; $R^2 = 87.25$), the minimum value of 1.687 mm Al was obtained with the addition of 488

FTU phytase, above which this value increased. In the distal epiphysis ($y = 1.8051 - 0.0021x + 0.000002x^2$; $R^2 = 63.00$), the inclusion of up to 525 FTU phytase determined reducing values, with the lowest at 1.234 mm Al; above 525 FTU phytase, the results obtained increased.

Catala-Gregori *et al.* (2006) observed that birds fed diets containing different total phosphorus levels and supplemented with phytase presented lower bone ash percentage.

Table 8 - Mean bone density evaluated in 21- to 42-day-old broilers fed different phytase levels.

Treatments	Bone density from 22 to 42 days of age		
	Proximal epiphysis (mm Al) ²	Diaphysis (mm Al) ³	Distal epiphysis (mm Al) ⁴
Control	2.3556	2.2274	1.9164
250 FTU/kg	1.8357	1.6669	1.1824
500 FTU/kg	1.7429	1.7441	1.2006
750 FTU/kg	2.0171	2.1942	1.5058
1000 FTU/kg	1.8748	2.2707	1.4196
F value ¹	5.57**	8.09**	9.81**
CV (%)	16.34	15.97	20.82

1 ** - significant ($p < 0.01$). 2 - Quadratic effect of phytase level: $y = 2.2897 - 0.00157x + 0.000001x^2$; ($R^2 = 67.92$). 3 - Quadratic effect of phytase level: $y = 2.1621 - 0.00195x + 0.000002x^2$; ($R^2 = 87.25$). 4 - Quadratic effect of phytase level: $y = 1.8051 - 0.0021x + 0.000002x^2$; ($R^2 = 63.00$).

Table 9 shows mean quantitative and qualitative traits of the excreta of broilers. Data analyses detected a significant linear effect of phytase levels ($p < 0.01$) only in ingested ($y = 4.22 - 0.0008x$; $R^2 = 92.60$) and excreted ($y = 3.1347 - 0.0011x$; $R^2 = 94.90$) phosphorus levels, indicating that ingested and excreted phosphorus percentages decreased as dietary phosphorus level increased. Possibly there was a higher utilization of minerals when phytase was included at higher levels, decreasing excreta mineral content. On the other hand, dietary phytase levels did not influence the other studied traits ($p > 0.05$).

Table 9 - Mean quantitative (DMI and DME) and qualitative (PI, NI, PE, and NE) characteristics of the excreta of broilers, on dry matter basis.

Treatments	Excreta quantitative and qualitative characteristics					
	DMI(g)	PI(g) ²	NI(g)	DME(g)	PE(g) ³	NE(g)
Control	648	4.14 A	20.65	173	3.06 A	10.98
250 FTU/kg	640	4.03 A	21.13	162	2.84 AB	10.76
500 FTU/kg	659	3.89 A	20.45	182	2.70 AB	11.82
750 FTU/kg	685	3.70 AB	21.31	188	2.34 BC	11.14
1000 FTU/kg	659	3.29 B	22.52	185	1.88 C	11.80
F value ¹	0.57ns	6.34**	1.35ns	2.51ns	14.77**	0.22ns
CV (%)	8.41	8.52	8.04	9.66	11.48	7.51

Means followed by different letters in the same column are significantly different ($p < 0.05$) by the test of Tukey. 1 - ns - not significant ; ** - significant ($p < 0.01$). 2 - Linear effect of phytase level: $y = 4.22 - 0.0008x$; ($R^2 = 92.60$). 3 - Linear effect of phytase level: $y = 3.1347 - 0.0011x$; ($R^2 = 94.90$). DMI - dry matter ingestion, DME - dry matter excretion; PI - phosphorus ingestion, NI - nitrogen ingestion; PE - phosphorus excretion, NE - nitrogen excretion.



When the control treatment phosphorus ingestion and excretion results were compared to the other treatments, phosphorus ingestion reductions of approximately 3, 6, 11, and 21% were observed, with consequent decreases in phosphorus excretion of 7, 12, 23, and 39%. The highest level of phytase inclusion resulted in the lowest phosphorus excretion ($p < 0.01$), which is beneficial for the environment. However, when phytase was included in levels higher than 250 FTU/kg feed, broiler performance was compromised.

CONCLUSIONS

The inclusion of 250 FTU phytase/kg feed ensured good broiler performance; however, above this level, phytase had a negative impact on live performance and bone development. The availability of nutrients in the commercial product, as indicated by the manufacturer, may have determined these results, suggesting that the product nutritional matrix should be reviewed, and the need of further studies with the product

REFERENCES

- Angel R, Saylor WW, Mitchell AD. *et al.* Effect of dietary phosphorus, phytase, and 25 - hydroxycholecalciferol on broiler chicken bone mineralization, litter phosphorus, and processing yields. *Poultry Science* 2006; 85:1200-1211.
- Banks KM, Thompson KL, Jaynes P. *et al.* The effect of copper on the efficacy of phytase, growth, and phosphorus retention in broiler chicks. *Poultry Science* 2004; 83:1335-1341.
- Borges FMO. Utilização de enzimas em dietas avícolas. Caderno Técnico da escola de Veterinária da UFMG 1997; (20):5-307.
- Catalá-Gregori P, García V, Hernández F. *et al.* Response of broilers to feeding low - calcium and phosphorus diets plus phytase under different environmental conditions: Body weight and tibiotarsus mineralization. *Poultry Science* 2006; 85:1923-1931.
- Conte AJ, Teixeira AS, Fialho ET. *et al.* Efeito da fitase e xilanase sobre o desempenho e as características ósseas de frangos de corte alimentados com dietas contendo farelo de arroz. *Revista Brasileira de Zootecnia* 2003; 32(5):1147-1156.
- Denbow DM, Ravindran V, Konergay ET. *et al.* Improving phosphorus availability in soybean meal for broilers by supplemental phytase. *Poultry Science* 1995; 74:1831-18425.
- Lan GQ, Abdullah N, Jalaludin S. *et al.* Efficacy of supplementation of a phytase - producing bacterial culture on the performance and nutrient use of broiler chickens fed corn - soybean meal diets. *Poultry Science* 2002; 81:1522-1532.
- Louzada MJQ. Otimização da técnica de densitometria óptica em imagens radiográficas de peças ósseas. Estudos *in vitro* [tese]. Campinas (SP): Universidade Estadual de Campinas; 1994.
- Martinez-Amezcuca C, Parsons CM, Baker DH. Effect of microbial phytase and citric acid on phosphorus bioavailability, apparent metabolizable energy, and amino acid digestibility in distillers dried grains with solubles in chicks. *Poultry Science* 2006; 85:470-475.
- Onyango EM, Bedford MR, Adeola O. The yeast production system in which *Escherichia coli* phytase is expressed may affect growth performance, bone ash, and nutrient use in broiler chicks. *Poultry Science* 2004; 83:421-427.
- Payne RL, Lavergne TK, Southern LL. A comparison of two sources of phytase in liquid and dry forms in broilers. *Poultry Science* 2005; 84:265-272.
- Persia M E, Saylor WW. Effects of broiler strain, dietary nonphytate phosphorus, and phytase supplementation on chick performance and tibia ash. *Journal Applied Poultry Research* 2006; 15:72-81.
- Qian H, Veit HP, Konergay ET. *et al.* Effects of supplemental phytase and phosphorus on histological and other tibial bone characteristics and performances of broilers fed semi-purified diets. *Poultry Science* 1996; 75: 618-626.
- Rostagno HS. *et al.* Composição de alimentos e exigências nutricionais: tabelas brasileiras para aves e suínos. 2. ed. Viçosa: UFV; 2005. p.186.
- SAS INSTITUTE SAS. System for Microsoft Windows, Release 6.12. Cary, NC; 2002.
- Silva DJ. Análise de alimentos: métodos químicos e biológicos. 2.ed. Viçosa, MG: Universidade Federal de Viçosa; 1990.
- Tejedor AA, Albino LFT, Rostagno HS. *et al.* Efeito da adição da enzima fitase sobre o desempenho e a digestibilidade ileal de nutrientes. *Revista Brasileira Zootecnia* 2001; 30:802-808.
- Viveros A, Brenes A, Arijia I. *et al.* Effects of microbial phytase supplementation on mineral utilization and serum enzymes activities in broiler chicks fed different levels of phosphorus. *Poultry Science* 2002; 81:1172-1183.
- Wu YB, Ravindran V, Hendriks WH, Morel PCH, Pierce J. Evaluation of a microbial phytase, produced by solid state fermentation, in broiler diets. Influence on performance, toe ash contents, and phosphorus equivalency estimates. *Journal Applied Poultry Research* 2004; 13:373-383.