EFFECT OF AVAILABLE PHOSPHORUS LEVELS AND SOURCES OF PHOSPHATES ON THE PERFORMANCE AND BONE MINERALIZATION OF BROILERS

EFEITO DOS NÍVEIS DE FÓSFORO DISPONÍVEL E FONTES DE FOSFATOS SOBRE O DESEMPENHO E A MINERALIZAÇÃO ÓSSEA DE FRANGOS DE CORTE

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SUMMARY

The experiment was conducted to evaluate the effect of phosphate sources and available phosphorus levels present in the diet of male broilers had on performance and bone mineralization. We used 2,400 one-day old chicks that were distributed in a completely randomized design in a 4x4 factorial arrangement, and fed diets containing four types of phosphates: 1) dicalcium phosphate with granules smaller than 1 mm (DP); 2) monocalcium phosphate with up to 10% of granules between 1 and 2 mm (MP – 10%); 3) monocalcium phosphate with 30 to 40% of granules between 1 and 2 mm (MP – 30-40%); and, 4) granulated monocalcium phosphate with granules larger than 2 mm (GMP) and four levels (0.30; 0.36; 0.42 and 0.48%) of available phosphorus, totaling 16 treatments with five replicates of 30 birds each. The available phosphorus requirements for each type of phosphates were estimated by polynomial regression models. Considering the biological responses of the variables, performance and bone mineralization, it could be concluded that 0.48% of available phosphorus is required for male broilers aged between 1 and 28 days, independent of the source.

KEY-WORDS: Calcium. Feed conversion. Tibiotarsus.

RESUMO

Um experimento foi conduzido com o objetivo de avaliar os efeitos de tipos de fosfatos e níveis de fósforo disponível, na alimentação de frangos de corte machos de 1 a 28 dias de idade sobre o desempenho e a mineralização óssea. Dois mil e quatrocentos pintos com um dia de idade foram distribuídos em um delineamento inteiramente casualizado em esquema fatorial 4x4, com quatro tipos de fosfatos: 1. fosfato bicálcico em pó com grânulos menores do que 1 mm (FP); 2. fosfato monobicálcico mistura com máximo de 10% grânulos entre 1 e 2 mm (FM – 10%); 3. fosfato monobicálcico mistura com máximo de 30 a 40% de grânulos entre 1 e 2 mm (FM – 30 a 40%); 4. fosfato monobicálcico granulado com grânulos maiores que 2 mm (FMG) e quatro níveis (0,30; 0,36; 0,42 e 0,48% de fósforo disponível), totalizando 16 tratamentos com cinco repetições de 30 aves cada. As exigências em fósforo disponível dentro de cada tipo de fosfato utilizado foram estimadas por intermédio dos modelos de regressão polinomial. Considerando as respostas biológicas, para as variáveis de desempenho e características ósseas, pôde-se sugerir que a exigência de fósforo disponível, para frangos de corte machos, de 1 a 28 dias de idade, é de 0,48% de fósforo disponível, independente da fonte utilizada.

PALAVRAS-CHAVE: Cálcio. Conversão alimentar. Tibiotarso.

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INTRODUCTION

Phosphorus performs multiple functions in the metabolism, particularly in the early stages of growth and it is one of the nutrients with great impact on the cost of poultry feed (BORGES, 1997). Phosphorus together with calcium are vital elements in the formation of bones. There are now in the market different types of phosphates, especially mono, dicalcium phosphate or a mixture of both, depending on the mixture. Among the sources of phosphorus, the most widely used by nutritionists is dicalcium phosphate.

The choice of a phosphorus supplement should take into account the cost per unit, the chemical form in which the element is present, particle size, solubility and impurity levels (VIANA, 1985). An important factor that can affect the bioavailability of phosphorus is the phosphate particle size, since the larger the particle size, the greater the bioavailability of the element (GRIFFITH & SCHEXNAILDER, 1970; POTTER, 1988).

Therefore, this study aimed to evaluate the effects that four types of phosphates, added at four different levels of available phosphorus in the diet of broilers, had on the performance parameters and the mineral contents (ash, calcium and phosphorus) of the tibiotarsus.

MATERIAL AND METHODS

The experiment was conducted in the experimental facilities (poultry and abattoir) of the Faculdade de Ciências Agrárias e Veterinárias of Unesp, in Jaboticabal, from June 11 to July 8, 2008. We used 2,400 one-day-old broiler chicks that were housed in a shed with 80 plots that had 30 birds each. The Cobb chicks were reared from 1 to 28 days old.

The experimental design was completely randomized in a 4x4 factorial, with four types of phosphates: 1) dicalcium phosphate powder with granule smaller than 1 mm (DP); 2) monodicalcium phosphate mixture with up to 10% of granules between 1 and 2 mm (MP – 10%); 3) phosphate monodicalcium mixture with up to 30-40% of granules between 1 and 2 mm (MP – 30-40%); and, 4) monodicalcium phosphate with granules larger than 2 mm (GMP), and with four levels of available phosphorus (0.30; 0.36; 0.42 and 0.48%), totaling 16 treatments with five replicates each. All phosphate types were previously analyzed in order to formulate the diets (Table 1).

The basis of the experimental diets was corn and soybean meal, as the source of energy and protein, respectively, as recommended by Rostagno et al. (2005) for male broilers, differing only regarding the levels of available phosphorus (Table 2). Thus, within each level of available phosphorus, the experimental diets had the same nutritional value, regardless of the type of phosphate used. Because of the similarity between the chemical composition of the phosphates, we prepared a basal diet for each level of available phosphorus containing ground rice hulls as the inert.

At the end of the experimental period (28 days), the broilers were weighed, and feed intake, feed conversion, average weight and production viability were determined. Four birds were chosen randomly from each plot, totaling 16 birds per treatment and 320 birds in total. They were individually tagged, left to fast during 8 hours, subsequently weighed and slaughtered. Samples of the right biotarsus of each bird were analyzed to determine bone ash, calcium and phosphorus levels.

The results were submitted to analysis of variance using the General Linear Model (GLM) of SAS® (2002). When analysis of variance results were significant ($p<0.05$), the Student-Newman-Keuls test was performed at 5%. The available phosphorus requirements for each type of phosphate were estimated by polynomial regression models.

Table 1 - Chemical composition of the phosphates

Phosphorus sources	*Calcium (%)*	*Phosphorus (%)*
DP	22.4	18.7
MP – 10%	20	20.5
MP – 30-40%	19	20.8
GMP	18.9	20.00

DP = dicalcium phosphate with granules smaller than 1 mm; MP – 10% = monocalcium phosphate with up to 10% of granules between 1 and 2 mm; MP – 30-40% = monocalcium phosphate with 30 to 40% of granules between 1 and 2 mm; GMP = granulated monocalcium phosphate with granules larger than 2 mm.

Table 2 - Proximate composition and calculated nutritional value of each diet.

Ingredients	*Available phosphorus (%)*			
	0.3	0.36	0.42	0.48
Corn	59.03	58.93	58.73	58.53
Soybean meal	36.4	36.5	36.5	36.6
Limestone	1.7	1.5	1.4	1.2
Soybean oil	1	1	1	1
Variable portion *	1	1.2	1.5	1.8
Common salt	0.4	0.4	0.4	0.4
Vitamin mineral supplement**	0.4	0.4	0.4	0.4
DL-Methionine (99%)	0.2	0.2	0.2	0.2
L-Lysine (78%)	0.07	0.07	0.07	0.07
Total	100	100	100	100

* The variable portion was the phosphorus source and/or inert, in order to adjust the available phosphorus levels.
** Nutrients per kilo: Vit. A 10.020 IU, Vit.D3 2.010 IU, Vit. E 15 mg, Vit. K3 2,50 mg, Vit. B1 1,5 mg, Vit. B2 5,01 mg, B6 1.5 mg, Vit. B12 12 mcg, Folic acid 0.6 mg, Biotin 0.05 mg, Niacin 35 mg, Calcium Pantothenate 11.22 mg, Copper 6 mg, Cobalt 0.10 mg, Iodine 1.02 mg, Iron 50 mg, Manganese 65 mg, Zinc 45 mg, Selenium 0.21 mg, Choline chloride (50%) 700 mg, Coccidicida 80 mg, Growth Promoter (zinc bacitracin) 80 mg, Antioxidant 12 mg and Vehicle (52.8%).
1 Calculated nutritional value: Energy (kcal/kg) 2,960; crude protein (%) 21.620; Calcium (%) 1.00; sodium (%) 0.220; total lysine (%) 1.234; lysine (%) 1.200 (%); total methionine (%) 0.564; digestible methionine (%) 0.549; total methionine + cystine (%) 0.924; digestible methionine + cystine (%) 0.910; threonine total (%) 0.838; threonine (%) 0.732.

Table 3 - Weight gain (WG), feed intake (FI), feed conversion (FC) and production viability (VC) of male broilers during 1-28 days of age.

Treatments[1]	***Evaluated traits***			
	WG (g)	FI	FC (g/g)	PV (g)
		Levels of available phosphorus (PL)		
0.30%	1157.62	2046.55	1.77	98.57
0.36%	1149.04	2041.34	1.78	96.88
0.42%	1193.88	2097.09	1.76	98.54
0.48%	1206.32	2086.66	1.73	98.33
		Types of phosphates (PT)		
DP	1217.75	2098.45	1.72	97.56
MP – 10%	1135.22	2022.59	1.78	98.75
MP – 30-40%	1198.78	2087.7	1.74	97.78
GMP	1155.1	2062.9	1.79	98.13
		F values		
Phosphorus levels	6.95*	1.10 NS	0.89 NS	1.83NS
Phosphate types	13.17*	1.58 NS	2.29 NS	0.75 NS
Interaction PT X PL	2.82*	1.03 NS	2.02*	1.16 NS
CV(%)	3.57	5.18	4.68	2.36

* significant at 5%; NS = non significant. [1] DP = dicalcium phosphate with granules smaller than 1 mm; MP – 10% = monocalcium phosphate with up to 10% of granules between 1 and 2 mm; MP – 30-40% = monocalcium phosphate with 30 to 40% of granules between 1 and 2 mm; GMP = granulated monocalcium phosphate with granules larger than 2 mm.

RESULTS AND DISCUSSION

There were significant interactions between the levels of available phosphorus and the type of phosphate used for the traits weight gain and feed conversion ($p<0.05$) (Table 3).

In the diet containing monodicalcium phosphate mixture with up to 30-40% of granules between 1 and 2 mm, the available phosphorus levels and weight gain increased linearly according to the equation: GP = 640.95x + 948.81 (R^2 = 0.80). The weight gain of the broilers fed the monodicalcium phosphate mixture with up to 10% granules between 1 and 2 mm quadratic effect with the studied levels of available phosphorus according to the equation: WG = $11406x^2 – 8595.6x + 2701.3$ (R^2 = 0.93). Due the behavior of the concave quadratic curve was not possible to estimate the optimal level of phosphorus available to obtain the maximum weight gain. Therefore, it was observes that the level of 0.48%phosphorus resulted in better results for weight gain, for both types of phosphate (Figure 1).

These results are in agreement with those of Cortelazzi (2006), who also studied different phosphorus sources (monodicalcium, dicalcium and monosodium phosphate) at two different availability levels (0.24 and 0.48%), during the early stages of growth (1 to 21 day- old birds), and reported highest weight gain for 0.48% compared to 0.24% of available phosphorus.

Queiroz et al. (2008) while studying different types of phosphates (defluorinated, monocalcium and dicalcium phosphate) supplemented at four different levels, 0.25%; 0.35%; 0.45% and 0.55%, also in the early stages of growth (1 to 21 day-old birds) reported that maximum weight gain was reached at 0.44% of available phosphorus.

Despite numerous studies conducted to determine broiler available phosphorus requirements, the results are still conflicting, and variables such as temperature, humidity, breed and management are the culprit for these contrasts.

For the phosphate mixture monodicalcium with beads up to 10% between 1 and 2 mm with respect feed conversion, different levels of phosphorus available demonstrated quadratic effect, according to the equation: CA= $- 15,233x^2 + 12,04x + 0,5259$ (R^2 = 0,93). The level of available phosphorus that maximized feed conversion was not estimated due to the behavior of the convex quadratic curve. The available phosphorus levels of 0.30 and 0.48% yielded the best feed conversion results (Figure 2).

FCR (feed conversion rate) of broilers fed monodicalcium phosphate mixture with up to 30-40% granules between 1 and 2 mm decreased linearly according to the equation: CA = - 0,8373x + 2,0681 (R^2 = 0,85), where the 0.48% level of available phosphorus maximized FCR (Figure 2). Queiroz et al. (2008) also reported the highest FCR for broilers aged between 1 and 21 days when the diet contained 0.45% of available phosphorus.

Feed intake and production viability were not significantly affected (Table 3) by either the different levels of available phosphorus or the different types of phosphates, and the interaction was not significant as well ($p>0.05$).

Table 4 - Ash (Cz), total phosphorus (Pt), calcium (Ca) and mineral matter (MM) in the tibia of male broilers at 28 days of age, based on dry defatted matter.

Trataments[1]	*Evaluated traits*			
	Cz (g)	Pt (%)	Ca (%)	MM (%)
	Phosphorus levels (PL)			
0.30%	16.15	17.58	35.27	99.47
0.36%	18.02	17.67	35.21	99.49
0.42%	18.08	17.71	35.03	99.52
0.48%	18.02	17.6	34.76	99.51
	Phosphate types (PT)			
DP	17.76	17.6	34.51	99.5
MP – 10%	17.37	17.58	35.44	99.5
MP – 30-40%	17.69	17.65	34.84	99.54
GMP	17.56	17.73	35.44	99.45
	F values			
Phosphorus levels	22.92*Q	0.43 NS	0.64 NS	0.37 NS
Phosphate types	0.75 NS	0.53 NS	1.85 NS	0.87 NS
Interaction PT X PL	0.71 NS	1.61 NS	1.92*	1.07 NS
CV(%)	7.03	3.28	5.98	0.23

* significant at 5%; NS = non significant. [1] DP = dicalcium phosphate with granules smaller than 1 mm; MP – 10% = monocalcium phosphate with up to 10% of granules between 1 and 2 mm; MP – 30-40% = monocalcium phosphate with 30 to 40% of granules between 1 and 2 mm; GMP = granulated monocalcium phosphate with granules larger than 2 mm.
*Q = quadratic regression effect (P<0.05).

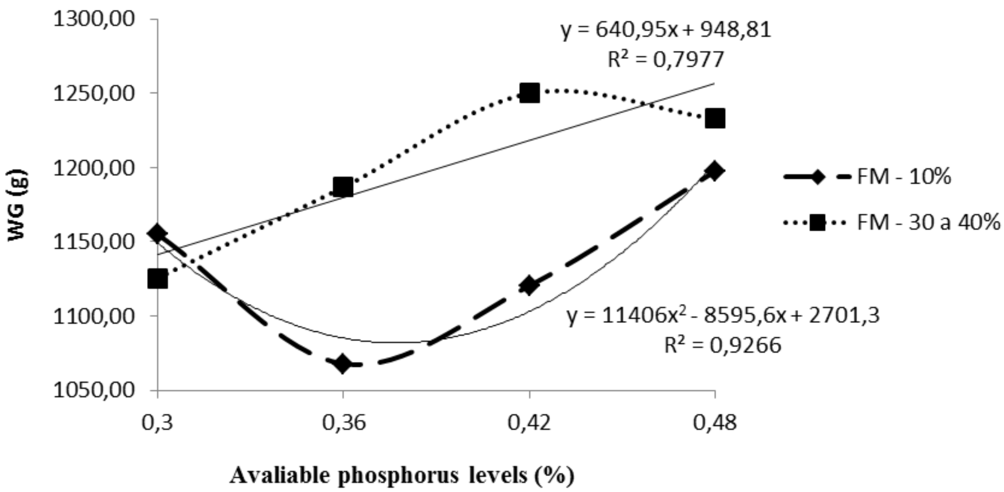

Figure 1 - Effect of available phosphorus levels on weight gain of birds from 1 to 28 days of age, for monodicalcium phosphate mixture with up to 10% granules of 1 to 2 mm (MP-10%) and monodicalcium phosphate mixture with maximum 30-40% granules between 1 and 2 mm (MP- 30-40%).

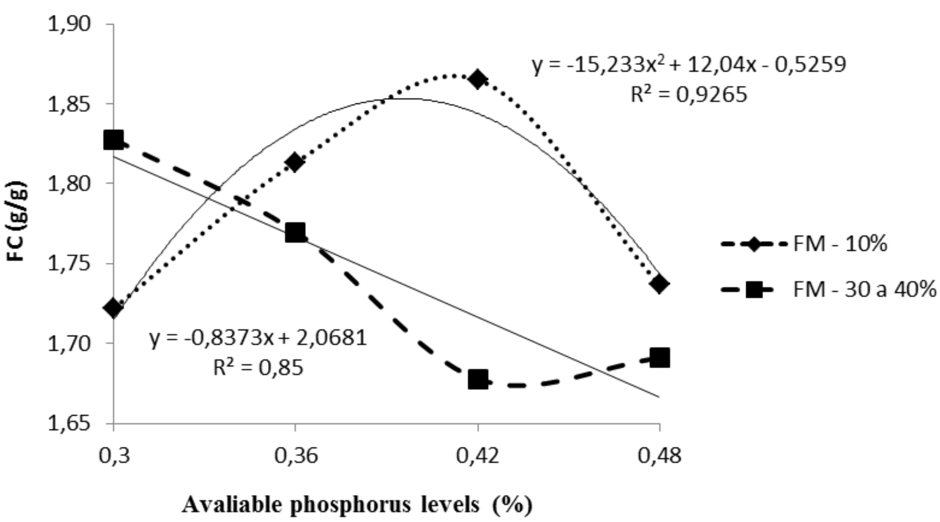

Figure 2 - Effect of available phosphorus levels on feed conversion of birds from 1 to 28 days of age, for monodicalcium phosphate mixture with up to 10% granules of 1 to 2 mm (MP-10%) and monodicalcium phosphate mixture with maximum 30-40% granules between 1 and 2 mm (MP- 30-40%).

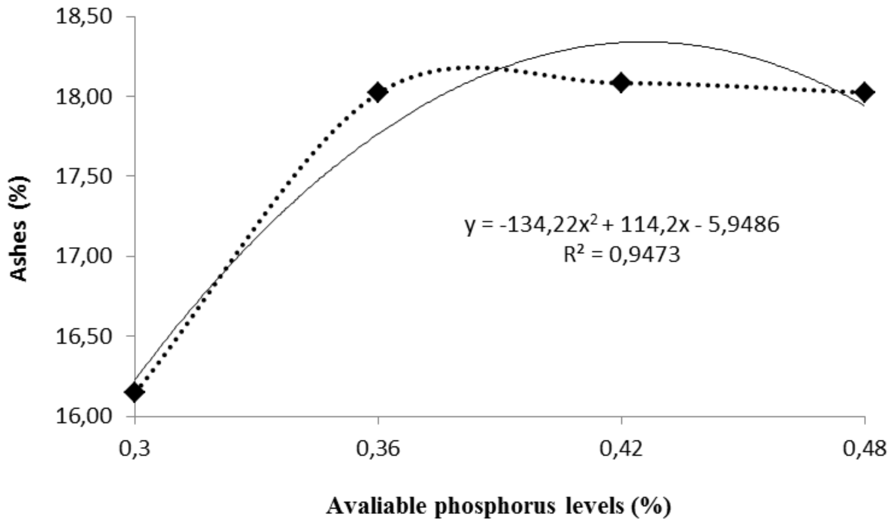

Figure 3 - Effect of levels of available phosphorus on the ashes tibiotarsus of broiler chickens at 28 days of age.

The results illustrated by quadratic regressions showed trends regarding the levels of available phosphorus present in the diet supplied to broilers between 1 and 28 days of age; however, the optimal values were not determined due to the curve behavior.

Ash content (Table 4) it was found that there was a quadratic effect on the levels of available phosphorus used ($p<0,05$), according to the equation: $Cz= - 134,22x^2 + 114,2x – 5,9486$ ($R^2 = 0,95$). Lima et al. (1995) also reported that the ash content in the femur increased with increasing levels of available phosphorus (0.15 to 0.45%), but remained practically constant when phosphorus level increased to 0.54%. Gomes et al. (1993) also reported increasing ash levels in the tiobiotarsus for up to 0.34% of available phosphorus, which remained constant when phosphorus levels increased to 0.42 and 0.50%.

Several authors, such as Libal et al. (1969), Koch et al. (1984) and Gomes et al. (1993), report that phosphorus requirements to optimize performance are lower than that required to maximize bone development. However, in the present study this hypothesis was not proven, since for performance variables the optimum phosphorus level was 0.48%. while for ash content in the tibiotarsus, the optimum level was reached before (Figure 3).

Despite significant interaction ($p<0.05$) between calcium content in broiler tibia and the types of phosphates used, there was significant regression effect within each type of used phosphate ($p>0.05$).

Total phosphorus content did not change significantly ($p>0.05$) for both the different levels of phosphorus and types of phosphate used (Table 4).

CONCLUSION

Considering the biological responses of the performance and bone variables, it can be suggested that the available phosphorus required for male broilers between 1 and 28 days old is 0.48% , independent of the source.

REFERENCES

BORGES, F.M.O. **Utilização de enzimas em dietas avícolas**. Caderno Técnico da escola de Veterinária da UFMG, Belo Horizonte, n.20, p.5-30, 1997.

CORTELAZZI, C. Q. L. **Fósforo disponível para frangos de corte em fosfatos para alimentação animal**. 62p. Dissertação (Mestrado) - Universidade de São Paulo, Pirassununga, 2006.

GOMES, P.C.; GOMES, M.F.M.; LIMA, G.J.M.M.; BELLAVER, C. Exigência de fósforo e sua disponibilidade nos fosfatos monoamônio e monocálcico para frangos de corte até 21 dias de idade. **Comunicado Técnico 198, EMBRAPA–CNPSA**, p. 1–2, 1993.

GRIFFITH G, SCHEXNAILDER R. The relation of dietary particle size to phosphorus availability in purified diets. **Poultry Science,** v. 49:p. 1271-74, 1970.

KOCH, M. E.; MAHAN, D. C.; COR-LEY, J. R. An avaluation of various biological characteristics in accessing low phosphorus intake in weanling swine. **Journal of Animal Science,** v. 59, p. 1546- 1556, 1984.

LIBAL, G. W.; PEO, E. R.; ANDREWS, R. P. Levels of calcium and phosphorus for growing-finishing swine. **Journal of Animal Science**, v.28, n.1, p.331-335, 1969.

PARMER, T. G., CAREW, L. B., ALTER, F. A. Thyroid function, growth hormone, and organ growth in broiler deficient in phosphorus. **Poultry Science**, 66:1995-2004, 1987.

POTTER LM. Biological values of phosphorus from various sources for young turkey. **Poultry Science,** v. 67, p. 96-102, 1988.

QUEIROZ, L. S. B.; BERTECHINI, A. G.; RODRIGUES, P. B.; GUERREIRO, M. C. **Utilização de fosfatos comerciais para frangos de corte na fase inicial.** Pesquisa Agropecuária Brasileira, v.43, n.10, p.1421-1427, 2008.

ROSTAGNO, H.S.; ALBINO, L.F.T.; DONZELE, J.L.; GOMES, P.C.; OLIVEIRA, R.F.; LOPES, D.C.; FERREIRA, A.S.; BARRETO, S.L.T. **Composição de alimentos e exigências nutricionais. (Tabelas Brasileiras para Aves e Suínos).** 2ª Edição. Viçosa: UFV, p. 186, 2005.

SAS INSTITUTE INC**. SAS System for Microsoft Windows,** Release 6.12. Cary. NC,. USA, 2002.

VIANA, J.A.C. Fontes de sais minerais para bovinos e o desafio de suplementos de fósforo no Brasil In: SIMPÓSIO SOBRE NUTRIÇÃO DE BOVINOS, 3, 1985. Piracicaba, **Anais...** Piracicaba**,** FEALQ, p. 47-66, 1985.