

Effect of diet phosphate source and phosphorus level on Ca and P utilisation of broilers at different ages and final tibia parameters

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Abstract

Ca and P utilisation of broilers was determined in a balance experiment performed at 9-13, 23-26 and 31-34 days of age and tibia parameters at the end of the study. Six diets arranged as a 2 x 3 factorial design consisting of two phosphate sources (monocalcium phosphate and dicalcium phosphate) and three levels of dietary phosphorus (0.54, 0.66 and 0.78% total P, respectively) were evaluated. Apparent Ca and P retention (% of intake) at 9-13 days of age was higher from MCP than from DCP, but between 23-26 and 31-34 days of age mineral retention from MCP and DCP was similar. Dietary phosphate source had no effect on tibia parameters. Retention per intake of Ca and P decreased with increasing dietary P level across all ages. Tibia ash, Ca and P contents and specific weight increased linearly with increasing dietary P level. However, dietary P level had no significant effect on tibia breaking strength.

Introduction

Environmental phosphorus (P) pollution has increased the pressure to minimize P excretion in livestock production. Reducing P excretion in broiler production is possible by using phytases and dietary phosphate sources with a higher content of available P. In many of the earlier studies P bioavailability or apparent P retention of broilers have been higher for monocalcium phosphate (MCP) than for dicalcium phosphate (DCP) (Potter et al. 1995, De Groote and Huyghebaert 1997). However, these parameters have typically only been determined in relatively young birds.

The aim of this study was to investigate the effect of mono- and dicalcium phosphate and dietary P level on calcium (Ca) and P utilisation and tibia parameters of broilers at three different stages of growth.

Materials and Methods

A 39-day experiment was carried with 144 Ross 508 broilers. Broilers were raised in 36 3-floor battery wire cages (size 47.5 x 56.0 x 40.0 cm), with four birds (2 males and 2 females) per cage. Six diets were arranged 2 x 3 factorially. The corresponding factors were diet phosphate source, monocalcium phosphate (monohydrate) or dicalcium phosphate (dihydrate) and three levels of dietary phosphorus (0.54, 0.66 and 0.78% total P, respectively). Calculated available phosphorus (AvP) contents were 0.25, 0.35 and 0.45% in MCP-diets and 0.24, 0.33 and 0.41% in DCP-diets, respectively, assuming 80 and 69% AvP in total P for MCP and DCP (Tuori et al. 2000) and 35, 47 and 42% non-phytate P of total P for wheat, barley and soybean meal (NRC 1994), respectively. Ca/AvP-ratio in all diets was formulated to be 2.0.

Birds were fed diets as 3-mm pellets. Diets contained wheat, barley, soybean meal, rapeseed oil, minerals, vitamins, amino acids and betaine (Betafin 0.07%). Chromium oxide was used as an indigestible marker in finisher diets. ME content of diets was 12 MJ kg⁻¹ and crude protein content 200 g kg⁻¹.

Mineral utilisation of broilers was determined at the 9-13, 23-26 and 31-34 days of ages by total excreta collection. Apparent ileal calcium and phosphorus digestibilities were assessed at 39 days of age using the slaughter technique. The left tibia of one bird from each cage was

removed for bone strength determination and the left tibias of two other birds per cage were submitted for ash, Ca and P determination.

Experimental data was subjected to analysis of variance using the GLM procedure of SAS with P source, P level and their interactions as fixed effects and cage as a random effect. Differences between diets were tested with single degree of freedom orthogonal contrasts. Treatment effects were considered significant at $p < 0.05$.

Results and Discussion

Apparent P retention (% of intake) for broilers fed MCP diets was higher ($p < 0.001$) than those for birds fed DCP diets during the first collection period at 9-13 days of age (Table 1). During the second (23-26 days) and third (31-34 days) collection periods, diet P source had no effect ($p > 0.05$) on Ca and P retention of broilers. This is in contrast with the results of De Groote and Huyghebaert (1997) who reported 5% higher P retention in MCP relative to DCP for broilers at 22-25 days of age. However, at the end of the experiment the apparent ileal P digestibility of broilers fed MCP diets was higher ($p < 0.001$) than that of birds fed the DCP diets. Broilers fed MCP diets were significantly heavier than those fed DCP during the first ($p < 0.01$), second ($p < 0.01$) and third ($p < 0.05$) collection periods, but not at the end of the study, when birds were 39 days old.

Although the absolute retention (g/bird/day) of Ca and P increased, the retention (as a proportion of intake) decreased with increasing diet P content at all ages. Dietary P content had a quadratic effect on Ca and P retention ($p < 0.01$ and $p < 0.05$) during the first collection period. During the second collection period retention of Ca and P decreased for MCP diets more rapidly than for DCP diets when diet P content increased (interaction C4, $p < 0.05$). A similar quadratic effect was seen for Ca and P retention (interaction C5, $p < 0.001$ and $p < 0.05$) during the third collection period. Apparent ileal digestibility of Ca and P also decreased linearly ($p < 0.001$) when diet P content increased.

Diet P source had no effects on tibia parameters. Earlier studies (Potter et al., 1995) indicated that the relative P bioavailability calculated from toe ash was significantly higher for MCP than DCP. However, tibia ash, Ca and P contents and specific weight increased linearly ($p < 0.01$) with increasing dietary P content. Dietary P level had no significant ($p > 0.05$) effect on tibia breaking strength.

Conclusions

Ca and P utilisation of broilers fed MCP and DCP was similar during the growing period, as measured at the 23-26 and 31-34 days of ages. Dietary P source had no effect on tibia parameters. Hence, the results indicate that the less expensive DCP source of P could be used to replace MCP in broiler grower diets. However, utilisation of P from MCP is higher for broilers during the 2 wk starter period.

References

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Table 1. Mean treatment effects on Ca and P retention (% of intake) and tibia parameters.

Phosphorus source	Mono		Di		SEM	C1	C2	C3	C4	C5
	0.54	0.66	0.78	0.54						
Total P, %	6	6	6	6	6					
Calcium										
Retention, % of intake										
9-13 days	62.6	52.2	48.0	59.3	49.7	48.2	1.14	0.056	0.001	0.145
23-26 days	65.1	56.1	50.4	61.6	55.3	52.4	1.06	0.387	0.078	0.016
31-34 days	59.2	56.8	47.1	59.7	50.7	51.1	0.94	0.466	0.563	0.076
Ileal digestibility, %										
39 day	43.0	28.3	27.3	41.4	26.5	20.1	3.15	0.183	0.053	0.382
Phosphorus										
Retention, % of intake										
9-13 days	58.3	51.6	47.9	54.7	48.4	44.5	0.71	0.000	0.041	0.878
23-26 days	59.7	55.0	51.0	58.2	54.5	54.8	1.04	0.481	0.205	0.017
31-34 days	55.9	53.3	48.6	55.4	50.6	49.1	0.66	0.110	0.627	0.438
Ileal digestibility, %										
39 day	56.4	50.3	47.0	52.1	45.4	39.1	1.67	0.000	0.623	0.295
Tibia										
Specific weight, g cm ⁻³	1.188	1.208	1.234	1.208	1.219	1.226	0.0082	0.280	0.942	0.092
Breaking strength, N	354	415	421	318	407	360	42.7	0.327	0.214	0.773
Ash g kg ⁻¹ DM	414	427	437	418	433	437	6.3	0.526	0.003	0.751
Ca g kg ⁻¹ DM	159	165	171	163	169	169	2.8	0.350	0.004	0.310
P g kg ⁻¹ DM	77	79	82	78	81	81	1.2	0.450	0.003	0.493

Mono=monocalcium phosphate (monohydrate), Di=dicalcium phosphate (dihydrate).

Contrasts C1=Mono- vs dicalciumphosphate, C2=Linear effect of total P, C3=Quadratic effect of total P, C4= interaction between C1xC2, C5= interaction between C1xC3.

SEM=Standard error of the mean.