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Effect of different phosphorus intakes on phosphorus balance and performance of layers during peak production

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ABSTRACT

Two experiments were conducted to determine the effect of different phosphorus supplies on phosphorus balance and performance of high performance layers. Both experiments were conducted with 72 HyLine layers (18 birds/treatment; 3 birds/cage). Hens were fed diets containing 2.5; 2.0; 1.5 and 1.0 g/kg non-phytate phosphorus (NPP). The calcium content was maintained constant at 32.5 g/kg. In the balance trial, the hens were 45 weeks of age (25 week of production). At the beginning of the performance trial the birds were 45 weeks old and were fed for 12 weeks. Absolute P retention was calculated subtracting the mean P excretion in the excreta from the P intake. Relative P retention was calculated absolute P retention dividing by P intake. Decreasing dietary NPP levels reduced P excretion in the excreta. Relative P retention was not influenced by levels of NPP. Decreasing dietary NPP reduced absolute P retention and P balance. Hens fed 1.5 and 1.0 g/kg NPP showed the lowest P balance at 43 and 39 mg/d, respectively, which was still adequate for the birds. Diets had no effect on feed intake, egg weight and feed per egg mass ($P \geq 0.05$). As NPP decreased from 1.5 to 1.0 g/kg, egg production and egg mass decreased ($P \leq 0.05$). It was concluded that dietary P content can be reduced up to 1.5 g/kg NPP without influencing the level of production, and at the same time the environment is also alleviated.
(Keywords: dietary phosphorus, phosphorus balance, phosphorus retention, egg production)

INTRODUCTION

Calcium and phosphorus are critical nutrients for ensuring maximum egg production and good eggshell quality. The calcium and phosphorus requirements for hens appear to be changing continuously. non-phytate phosphorus (NPP) requirements for laying hens have constantly declined during the last 40 years, in part due to increasing concern about environmental issues and pollution, which in certain countries led to strict legal limitations of P excretion. A number of researchers have reported that dietary phosphorus can be reduced without an adverse effect on performance (*Usayran* and *Balnave*, 1994; *Castillo et al.,* 2004; *Kovacs et al.*, 2006). Decreasing total phosphorus can reduce faecal phosphorus excretion, up to an estimated 20%, which is a significant goal to strive for in reducing potential phosphorus pollution problems (*Summers*, 1995). Results of *Scheideler* and *Jerry* (1986) showed that lower dietary phosphorus levels decreased absolute phosphorus retention, however, this finding is not consistent with the results of *Keshavarz* (1985), who found that while decreasing dietary phosphorus had no effect on absolute retention, it did increase the percentage retention. Egg shell quality is of major importance to the egg industry worldwide. A number of investigators have reported that low levels of phosphorus improved shell quality (*Usayran* and *Balnave*, 1994). The last *NRC* (1994) recommendation is 2.5 g/kg NPP. This may be in excess of the current requirements of the laying hen.

The effects of reduced dietary phosphorus levels still need to be investigated. The following experiments were conducted to determine the effect of different phosphorus supplies on phosphorus balance and performance of high performance layers during peak production.

MATERIALS AND METHODS

Balance trial

The experiment was conducted with a total of 72 HyLine layers (18 birds/treatment; 3 birds/cage) 45 weeks of age (25 weeks of production). Feed and water were provided *ad libitum* during the experiment. From the start of laying at 20 weeks to 45 weeks of age, the hens received the same diets as in the experiment. The diets contained 2.5; 2.0; 1.5 and 1.0 g/kg NPP. The calcium content was maintained constant at 32.5 g/kg (*NRC*, 1994). The levels of energy, crude protein, lysine and methionine were kept constant in all diets. Composition and nutrient content of diet ingredients are shown in *Tables 1*.

Table 1

Composition and nutrient contents of the experimental diets (g/kg)

Ingredient	**Treatments**			
	1	**2**	**3**	**4**
Corn	655.0	655.0	655.0	655.0
Soybean meal (CP: 47.3%)	214.0	214.0	214.0	214.0
Salt	31.6	33.0	34.5	36.1
Limestone	78.7	79.7	80.6	81.5
MCP	8.1	5.8	3.4	0.8
NaCl	3.7	3.7	3.7	3.7
Premix[1]	5.0	5.0	5.0	5.0
Lizin-HCl	1.3	1.2	1.2	1.3
DL-metionin	2.6	2.6	2.6	2.6
Total	**1000.0**	**1000.0**	**1000.0**	**1000.0**
Nutrient content				
AMEn (MJ/kg)[2]	11.4	11.4	11.4	11.4
Crude protein	163.1	163.0	163.0	163.1
Crude fat	24.0	24.0	24.0	24.0
Lysine[2]	8.8	8.8	8.8	8.8
Met + Cys[2]	7.8	7.8	7.8	7.8
Ca	**32.5**	**32.5**	**32.5**	**32.5**
Total P	4.9	4.3	3.8	3.2
Non-phytate P[2]	**2.5**	**2.0**	**1.5**	**1.0**

[1]Provided per kilogram: calcium 186 g; iron 20000 mg; zinc 15000 mg; iodine 90 mg; manganese 20000 mg; selenium 60 mg; copper 1600 mg; vitamin A 1935600 NE; vitamin D_3 387200 NE; vitamin E 3880 NE; vitamin K_3 388 mg; vitamin B_1 388 mg; vitamin B_2 1280 mg; vitamin B_6 520 mg; vitamin B_{12} 2.8 mg; calcium pantothenate 3200 mg; niacin 9040 mg; folic acid128 mg; biotin 28.5 mg; choline 59983 mg.

[2] Calculated values.

Total amount of excreta was collected and measured for 4 days. Feed consumption and daily egg production were recorded throughout the collection period. All eggs were individually weighed. At the beginning and end of collection period body weights were individually recorded.

Performance trial

The experiment was conducted with a total of 72 HyLine layers (18 birds/treatment; 3 birds/cage). Feed and water were provided *ad libitum* during the experiment. The trial started at 45 weeks of age (week 25 of production) and lasted for 12 weeks. From 20 to 45 weeks of age, the hens were fed the same diets as in the balance trial. Egg production was recorded daily. All eggs were collected and individually weighed. Feed consumption was determined weekly. Individual body weight and shell strength and thickness were measured every 4th week.

Chemical Analyses

The nutrient content of diets and dry matter for both balance and performance trials, calcium and phosphorus content of excreta and eggs were determined in according to *AOAC* (1999).

Calculations

Absolute P retention was calculated subtracting the mean P excretion in the excreta from the P intake. Relative P retention was calculated absolute P retention dividing by P intake.

Statistical analysis

Statistical analyses were carried out by variance analysis (*SAS*, 2001) for both balance and performance trials according to the following general model:

$$Y_{i,j}=\mu+A_i+e_i$$

Where: μ= overall mean; A_i= phosphorus levels (i=1,2,3,4); $e_{i,j}$= residual error.

In case of a significant treatment effect, mean differences were tested by Tukey test, at P=0.05 level.

RESULTS AND DISCUSSION

Data of the phosphorus balance and performance trials are shown in *Tables 2* and *3*.

Balance trial

Decreasing the dietary NPP had no effect on feed intake therefore the significant change in P intake is attributable to the different dietary P levels ($P\leq0.05$). At the NPP levels used, phosphorus excretion in the excreta were 341, 324, 285 and 242 mg/d respectively. A 40% (Treatment 3) and 60% (Treatment 4) reduction of the NPP level resulted in an approximately 16% and 30% reduction, respectively of P excretion in the excreta ($P\leq0.05$). This finding appears to agree with those of *Summers* (1995). As the dietary NPP decreased (from 2.5 to 1.0), absolute P retention decreased (from 197 to 130 mg/d) ($P\leq0.05$) but there was no significant effect on percentage retention (34.7% on average) ($P\geq0.05$). This finding was consistent with the results of *Scheideler* and *Jerry* (1986) but does not correspond with the results of *Keshavarz* (1986) who found on the contrary, that changing the dietary levels of phosphorus did not influence phosphorus retention in absolute terms, but had an effect on percentage phosphorus retention. Phosphorus excretion in the egg was not influenced by treatments in hens fed 2.5; 2.0 and 1.5 g/kg NPP ($P\geq0.05$), however, it was lower in hens fed 1.0 g/kg NPP because the egg production of those hens decreased. Decreasing NPP from 2.5 to 2.0 and 1.5 g/kg, respectively decreased the phosphorus balance from 94 to 66 and 43 mg/d, respectively (both reductions were significant at $P\leq0.05$). The further reduction of dietary NPP did not decrease the phosphorus balance any further.

Table 2

Influence of dietary non-phytate phosphorus on the results of the balance (mg/d)

Items	Treatments				
	1	2	3	4	RMSE*
P intake	537^{a}	485^{b}	430^{c}	371^{d}	13
P excretion in the excreta	341^{a}	324^{a}	285^{b}	242^{c}	15
P retention	197^{a}	161^{b}	145^{cb}	130^{c}	11
P retention (%)	36.6^{a}	33.3^{a}	33.7^{a}	35.0^{a}	2.3
P excretion in the egg	102^{a}	95^{ab}	102^{a}	90^{b}	6
P balance	94^{a}	66^{b}	43^{c}	39^{c}	10

* : Root mean square error.
$^{a\text{-}d}$: Means in each row without common superscript differ ($P\leq0.05$).

Performance trial

Feed consumption was not influenced by treatments ($P\geq0.05$; *Table 2*). This finding was not consistent with the results of *Sohail* and *Roland* (2002), where feed consumption was lower when 1.0 g/kg NPP was fed. Average egg production did not change (95%) in layers fed 2.5; 2.0 and 1.5 g/kg NPP. *Usayran* and *Balnave* (1994) and *Summers* (1995) found the same.

Table 3

Influence of dietary non-phytate phosphorus on the results of the performance trial

Items	Treatments				
	1	2	3	4	RMSE*
Feed intake (g/d)	120^{a}	117^{a}	120^{a}	113^{a}	7
Egg production (%)	95.9^{a}	94.6^{a}	94.7^{a}	86.9^{b}	4.0
Egg weight (g/egg)	64.2^{a}	63.2^{a}	64.8^{a}	62.9^{a}	2.0
Egg mass (g/d)	61.5^{a}	59.8^{a}	61.3^{a}	54.7^{b}	3.6
Feed per egg mass (kg/kg)	1.93^{a}	1.96^{a}	1.95^{a}	2.07^{a}	0.10
Shell strength (kg/egg)	2.96^{a}	2.74^{a}	2.80^{a}	2.88^{a}	0.86
Shell thickness (mm)	0.333^{a}	0.325^{a}	0.325^{a}	0.323^{a}	0.030

* : Root mean square error.
$^{a,\,b}$: Means in each row without common superscript differ ($P\leq0.05$).

Leeson et al. (1993), however, found that when the total phosphorus levels were reduced from 5.8 to 5.1 g/kg egg production increased, these total P levels, however, were considerably higher than the levels fed in our trial. As NPP decreased from 1.5 to 1.0 g/kg, egg production decreased (P≤0.05), this result is consistent with the findings of *Sohail* and *Roland* (2002). Egg weight was not significantly affected by dietary levels of NPP (P≥0.05) in contrast to *Sohail* and *Roland* (2002). They found that reducing NPP from 3.0 to 1.0 g/kg decreased egg weight. Egg mass showed the same tendency as egg production, with a reduction when hens were fed 1.0 g/kg NPP (P≤0.05). On average, 1.98 kg of feed was used for producing 1 kg of egg mass. Diets had no effect on egg shell strength and thickness (P≥0.05).

CONCLUSION

It can be concluded from the balance trial that the decreasing dietary NPP levels reduce P excretion in the excreta. Decreasing the dietary NPP reduced absolute P retention and P balance. Hens fed 1.5 and 1.0 g/kg NPP showed the lowest P balance at 43 and 39 mg/d, respectively, which was still adequate for the birds. Results of the performance trial show that reduction of NPP from 2.5 to 1.5 g/kg had no effect on egg production, a further reduction to 1.0 g/kg, however, decreased egg production.

Dietary P content can be reduced up to 1.5 g/kg NPP without influencing the level of production, and at the same time the the environment is also alleviated. Therefore we suggest to feed layers in peak production with diets containing 1.5 g/kg NPP.

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