

CAN PHYTASE FULLY REPLACE INORGANIC PHOSPHORUS IN PRACTICAL BROILER NUTRITION?

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INTRODUCTION

Increasing environmental pressure and tightening legislation to decrease the phosphorus (P) load into the environment lead to re-think mineral nutrition of livestock. The first and seemingly logical move in that direction is to decrease inorganic feed phosphate (IFP) levels in the diets of high producing livestock: less P in the feed for less P excreted. Simultaneously, in order to use optimally the vegetal P linked to phytate in raw materials, the use of phytase has followed in an effort to meet animals' P requirements. During the last decade however, slaughterhouses have noticed an increased incidence of fragile and brittle bones from pigs and poultry. Similar incidences was noticed and reported by integrated companies.

Various management and nutritional approaches are being followed in an effort to reduce the P content in the manure of high producing livestock to a minimum. One of the most significant approaches is the lowering of P norms. Animals are today fed near their P requirements. Safety margins have almost disappeared, therefore leaving very little room for the effect of e.g. diet interactions, varying phosphorus and phytate phosphorus content of feedstuffs, individual animal needs and wrong calculation of the digestible P content in diets. This approach can lead to an under supplementation of essential P, offering a possible explanation for the incidences noticed by e.g. the slaughterhouses.

Formulating within very narrow safety margins leads to two critical questions: 1) "Is the P requirement accurate and well determined?" 2) "Can we be certain that the exact P requirement is met by the diet fed?" The latter is especially valid, considering that environmental pressure can result in relying almost entirely on the use of phytase as the sole phosphate source used to meet the P requirements of high producing animals. However it is important to remember that P digestibility and phytase inclusion levels do not follow a linear relationship. Consequently, the phosphate equivalent values for poultry of some commercial phytase sources, if not correctly applied, can lead to lower P supply than expected. This is a fact often underestimated or ignored by nutritionists and for simplicity reasons only one matrix value for all phytase inclusion levels is often used in practical broiler diets.

Feeding P below the requirement of the animal will have an immediate effect on the general health, hence also the production performance and bone strength. Evidently, any impairment of the general health of high producing livestock has significant economical

consequences. The need for adequate P nutrition has therefore become more crucial than ever.

The sector group, inorganic feed phosphates in CEFIC has in the light of this concern, conducted a study, in broilers diets consisting of two parallel studies, a growth and a balance study. The objective of these studies was to investigate the possibility to meet the P requirements of broilers by including a commercial phytase as only phosphate source and by following one simple matrix for P equivalent value. The studies compared the effect of different P sources (two inorganic P sources and a phytase source) on the growth performances, bone parameters and P retention in broiler chicken diets during a starter, grower and finisher period (0-42 day of age).

THE STUDY

Two parallel studies were conducted, a growth study and a balance study. Three experimental diets and a control diet were formulated to contain equal amounts of absorbable P according to recommended values (CVB, 2000).

Birds and housing

In the **growth study** 308 male broilers (768 Ross) were reared in floor pens of 32 chickens per pen for up to 42 days of age. A conventional lighting schedule of 23 h of light and 1 h of darkness was used. Water and pelleted feed was freely available to all birds during the entire trial.

In the **balance study**, 336 male broilers were placed on deep litter from day 1 to 10 on their respective diets. On day 10, the birds were placed on balance cages after being weighed individually. Each replicate consisted of two adjacent cages. Groups of 14 birds per replicate were assigned randomly to each of the 30x2 balance cages for an adaptation period of 4 days. This adaptation period was followed by 4 main periods of an entire week. During these periods the birds were fed at a nearly *ad libitum* level, while water was freely available. Lighting and temperature schedule were identical to the growth trial.

Diets

In both trials, a normal standard poultry feed based on wheat and soybean meal (SBM) was used with endogenous phytine-P as a target nutrient for the supplemented phytase.

In treatment 1-3, the absorbable phosphorus content (P_a , CVB 1997) was calculated to be 3.9; 2.9 and 2.7 g/kg for the starter, grower and finisher diet, respectively, based on the requirements for broiler chickens (CVB, 2002). In all these diets the absorbable P coming from the raw materials was calculated as 1.5 g P_a /kg. The balance available P for the 3 diets, i.e. 2.4, 1.4 and 1.2g/kg P_a was supplemented by either, dicalcium phosphate

dihydrate (DCP, Aliphos® Dical), monocalcium phosphate (MCP, Aliphos® Monocal) or the microbial phytase (Natuphos® 5000G,) for the three different growth periods, respectively. Treatment 4 consisted of a low P diet, which was used as a negative control.

Table 1. *Ingredient composition and calculated nutrient composition of the respective starter (ST), grower (GR) and finisher (FI) diets (g/kg, unless otherwise stated)*

Ingredients	DCP Treatment 1			MCP Treatment 2			Natuphos 5000G Treatment 3			Negative control Treatment 4		
	ST	GR	FI	ST	GR	FI	ST	GR	FI	ST	GR	FI
Wheat	604.3	629.7	641.0	600.1	627.5	638.8	601.8	630.0	643.8	611.9	637.8	648.7
Soya bean meal (48 % CP)	292.0	276.1	250.7	293.0	276.6	251.2	290.0	270.3	245.0	290.1	274.1	248.8
Soya bean oil	30.9	35.0	34.8	30.6	35.1	34.8	28.0	35.0	34.7	31.5	34.9	34.6
Animal fat	30.4	25.8	40.3	32.4	26.5	41.2	20.0	18.2	32.0	26.9	23.0	37.5
Cellulose							29.1	19.3	16.9			
CaCO ₃	8.8	7.6	7.0	14.4	10.8	9.9	14.1	10.7	9.8	14.3	13.8	12.6
NaCl	2.8	2.9	2.4	2.8	2.9	2.4	2.9	2.9	2.4	2.8	2.9	2.3
NaHCO ₃	0.5	0.0	0.8	0.5	0.0	0.8	0.3	0.0	0.8	0.5	0.0	0.8
L-lysine-HCl	1.5	1.8	2.4	1.5	1.8	2.4	1.2	1.8	2.4	1.5	1.8	2.4
DL-methionine	1.8	1.5	1.7	1.8	1.5	1.7	1.8	1.5	1.7	1.8	1.5	1.7
L-threonine	0.5		0.2	0.5		0.2	0.3		0.1	0.5		0.2
MCP				12.2	7.1	6.3						
DCP	16.2	9.5	8.5							8.0		
Natuphos 5000G							0.21⁴	0.12⁴	0.11⁴			
Vitamin/trace mineral mix ¹	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Biofeed wheat	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Nutrients												
AME _n , MJ/kg	12.30	12.50	12.85	12.30	12.50	12.85	12.30	12.50	12.85	12.30	12.50	12.85
CP	210.0	205.0	195.0	210.0	205.0	195.0	213.0	205.0	195.0	210.0	205.0	195.0
Lysine _{ad} ²	10.8	10.7	10.5	10.8	10.7	10.5	10.8	10.7	10.5	10.8	10.7	10.5
Methionine _{ad} +Cystine _{ad}	7.9	7.5	7.4	7.9	7.5	7.4	7.9	7.5	7.4	7.9	7.5	7.4
Ca	8.8	6.6	6.1	8.8	6.6	6.1	8.8	6.6	6.1	8.8	6.6	6.1
P _t	6.8	5.6	5.3	6.7	5.5	5.2	3.9	3.8	3.7	5.3	3.9	3.7
P _a from P supplements	2.4	1.4	1.2	2.4	1.4	1.2	2.4	1.4	1.2	1.2		
P _a available from raw materials	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
P _a (CVB, 1997) ³	3.9	2.9	2.7	3.9	2.9	2.7	3.9	2.9	2.7	2.7	1.5	1.5
Na	1.4	1.3	1.3	1.4	1.3	1.3	1.4	1.3	1.3	1.4	1.3	1.3
K	9.1	8.9	8.4	9.2	8.9	8.4	9.1	8.8	8.3	9.1	8.9	8.4
Cl	2.3	2.4	2.2	2.3	2.4	2.2	2.3	2.4	2.2	2.3	2.4	2.2
Na+K-Cl, meq	231	218	210	231	218	210	229	214	207	230	216	209
C18:2, %	2.5	2.7	2.8	2.5	2.7	2.8	2.3	2.6	2.7	2.5	2.7	2.8

¹ The vitamin/mineral premix provided the following quantities (mg/kg of diet): retinol, 4.05; cholecalciferol, 0.05; tocopherol, 13.5; menadione, 2.25; thiamin, 1; choline, 375; riboflavin, 5.4; pantothenic acid, 13.5; pyridoxine, 1.1; cyanocobalamin, 0.01; nicotinic acid, 40; biotin, 0.15; I, 2.1; Co, 1.4; Se, 0.43; Cu, 7.2; Mn, 86; Zn, 57; Fe, 65; Mg, 110.

² ad = apparent digestible

³ Based on the absorbability coefficient of P of the different ingredients measured in broilers under standard conditions (21-24 d of age, semi-synthetic diet with an absorbable P-content of 1.8 g/kg and a Ca-content of 5.0 g/kg) and corrected for practical concentrations of P_a and Ca

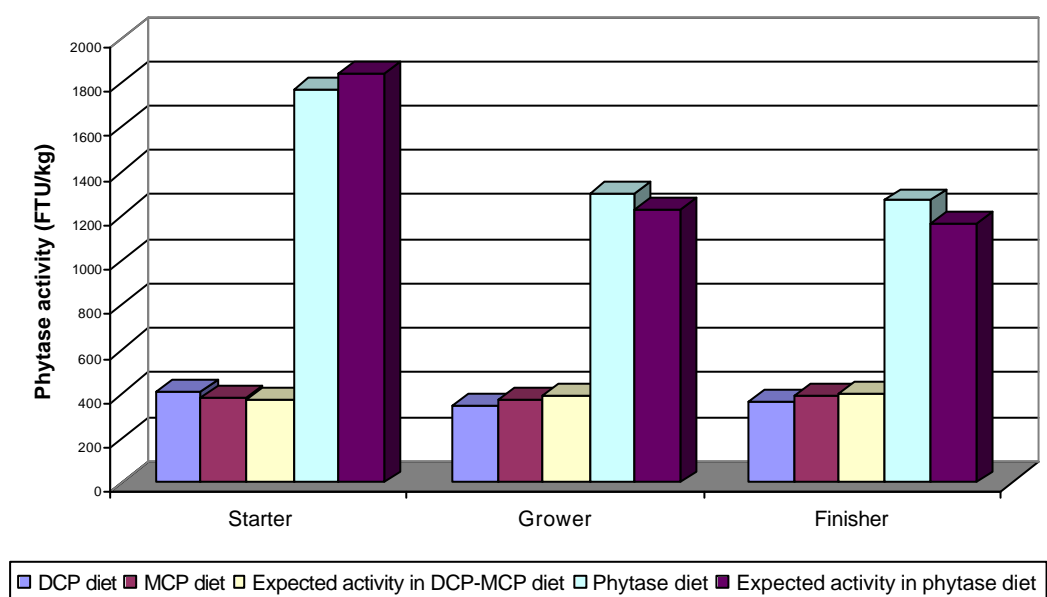
⁴ Natuphos 5000G: analysed phytase-activity of 6980 FTU/g; 0.8 g P_a/500 FTU

P-digestibility values used for the mineral P-sources were 80% and 85% for DCP and MCP respectively (De Groote and Huyghebaert, 1997; Lippens and Huyghebaert, 2002). For phytase a P equivalency of 0.8 g digestible phosphorus (P_d)/500 FTU (phytase units) was followed as only matrix. The contribution of the phosphate sources and the resultant available phosphate levels in the 4 diets is summarised in table 1.

Theoretical and analysed phytase – activities of the diets

All diets were pelleted at a temperature of ~ 79 °C, in order to ensure that no phytase activity was lost during processing. To determine if this was the case, the theoretical values of the expected phytase activities in the DCP and MCP supplemented diets were calculated by taking into account the wheat and soybean meal content of the diets. All diets indicated that calculated values were well in line with the analysed values of the diets, indicating that no phytase activity was lost during the pelleting of feed.

In **Figure 1**, the determined and expected FTU -values of the different diets are represented



Results and discussion

Results show that birds fed the phytase-supplemented diets were significantly lower in performance compared to the DCP and MCP treatments. The phytase treatment shows a lower feed intake (>15%), lower final body weight (2421g vs. 2668 and 2705g), body weight gain per day (56.6 vs. 62.4 and 63.3 g/day) and higher total mortality and culling (13% vs. 4.7 and 6.8%) in comparison with the DCP and MCP treatments respectively. The final body weight of the negative control was more than 25% lower than the

inorganic feed phosphate treatments, clearly confirming the important function of P in the broiler performance and welfare. The final body weight of the birds receiving the phytase supplemented diets were roughly 10% lower in comparison with the IFP diets, despite the fact that diets were formulated on the same amount of absorbable P. Results are summarised in Table 2.

Table 2. *Effect of the different phosphorus sources on feed intake, body weight gain, feed conversion and mortality between 1-42 days of age*

	Feed intake (g/d)	Body weight (g) after 42 days	Body weight gain (g/d)	FC	FC ₂₅₀₀	Mortality and culling (%)
DCP	108.1 ^a	2668 ^a	62.4 ^a	1.734 ^b	1.672 ^a	4.7 ^a
MCP	106.4 ^a	2705 ^a	63.3 ^a	1.683 ^{ab}	1.607 ^a	6.8 ^{ab}
Phytase	92.5 ^b	2421 ^b	56.6 ^b	1.635 ^a	1.664 ^a	13.0 ^b
Neg. control	75.1 ^c	1978 ^c	46.0 ^c	1.632 ^a	1.826 ^b	13.5 ^b
SEM	2.9	64	1.5	0.014	0.024	1.5
p-value	0.000	0.000	0.000	0.035	0.003	0.062

Treatment-effects on tibia ash (%) and P contents (mg and %) show similar results which are summarised in table 3. The Tibia ash (%) and P content (%) were significantly lower for the negative control and the phytase treatment in comparison to the IFP treatments. Tibia ash-% and P-% were not significant different for both inorganic P treatments.

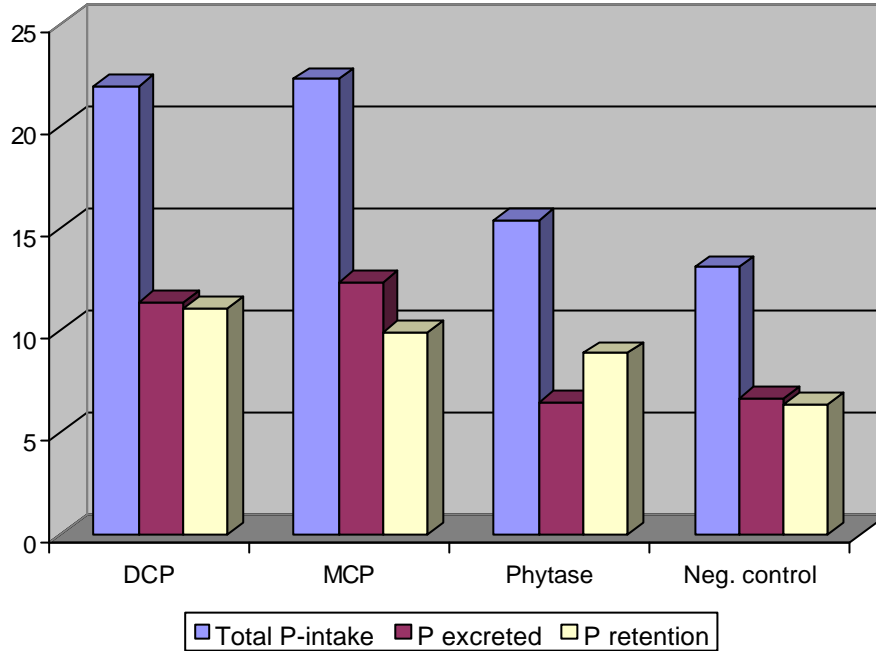
Table 3: *Effect of the different phosphorus sources on tibia ash and P contents 42 days of age (growth trial)*

	Tibia ash content (%)	Tibia P content (mg)	Tibia P content (%)
DCP	39.8 ^a	488.2 ^a	7.00 ^a
MCP	40.2 ^a	471.3 ^a	7.05 ^a
Phytase	37.6 ^b	398.7 ^b	6.51 ^b
Neg. control	35.3 ^c	298.0 ^c	5.87 ^c
SEM	0.55	16.6	0.11
p-value	0.000	0.000	0.000

Results from the balance trial showed a similar trend and indicated a significantly higher total P retention (g/bird) for the treatments with the inorganic P sources in comparison with the phytase supplemented diet and the negative control. See figure 2.

This means that those birds receiving the inorganic P sources retained more P and this might possibly explain the better growth rates and the higher P content in the tibiae of the birds.

In Figure 2 The effect of different P sources on the absolute P balance of the bird.



DISCUSSION

Results indicate that although all diets, with the exception of the negative control, were formulated to have a similar nutrient composition (absorbable P), some significant differences in production performances exist.

Considering tibia-ash-contents, the phytase supplemented diet lead to a significantly lower P content in the tibiae. This might indicate that this diet provided a lower amount of available P than expected when compared to the mineral P sources. This hypothesis is further supported in the balance trial, which showed that the absolute amount of P (g) retained in the bird for the phytase-supplemented diet was much lower ($p < 0.05$) than the feed phosphates supplemented diets.

This agrees with the findings of various researchers, who also found an unexpectedly low efficacy of different phytase sources in chick diets (Simons *et al.* 1990, Angel *et al.* 2001, Augspurger, *et al.* 2003). The significantly weaker performance of the phytase treatment is linked to the fact that the same matrix for phytase (0.8 g digestible P for 500 FTU) was used throughout the whole trial, which was not sufficient to allow an optimal supply of P. This goes in line with the well-documented fact that the relationship between the amount of phytase and the released amount of digestible P from phytine follows a non-linear relationship.

Conclusion:

The current trial, confirmed that P release from phytine by use of microbial phytase, based on a standard of 0.8 g digestible P for 500 FTU, lead to lower absorbable (digestible) P release than expected. Results indicate that relying on such Phytase as only source of P in order to ensure the full supply of phosphorus in broiler diets is not a reliable option. Phosphate equivalency values of phytase are possibly over estimated and the effect of phytase influenced by age and physiological status of animals. This study supports the fact that the predictable and known digestible P value of IFP sources provides "insurance" for adequate P supply in modern day broiler diets.

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