

Influence of superdoses of phytase on growth performance, dietary energy and nutrient availability, and inositol phosphate isomers in young turkeys

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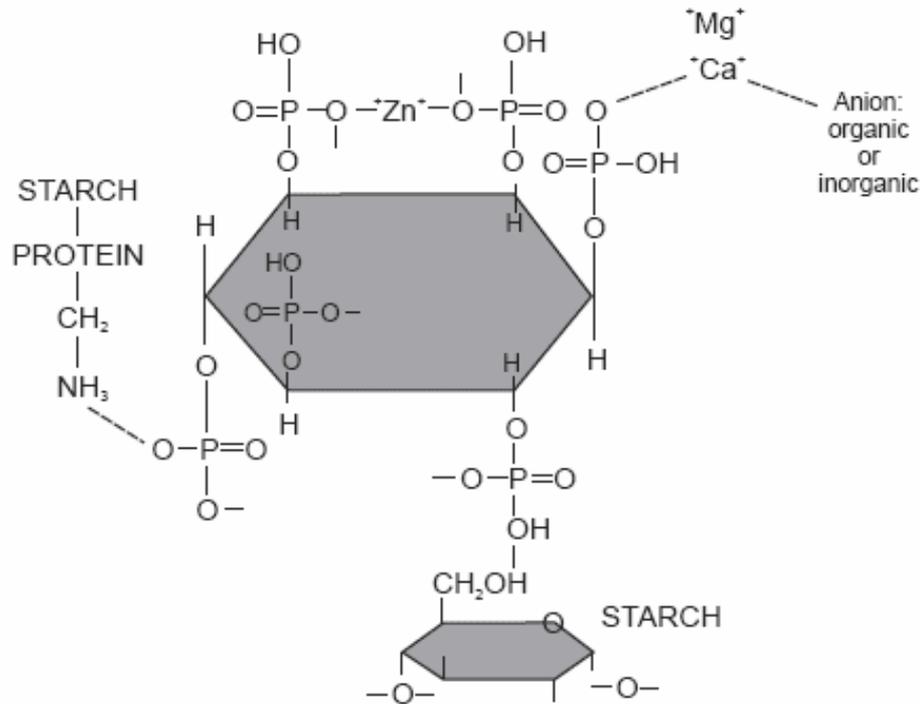
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Phosphorus

Phosphorus (P) is an essential mineral for growing turkeys, and a lack of adequate supply of available P in diets may reduce performance and carcass quality, and increase mortality



Phytate



Approximately 70% of plant P is organically-bound in a complex form, phytin - including phytic acid and phytates (salts of phytic acid), which is not available to pigs and poultry, because they do not produce sufficient amount of endogenous phytase

Phytate chelates divalent cations, react with protein and starch and reduce their bioavailability

Phytate is an irritant

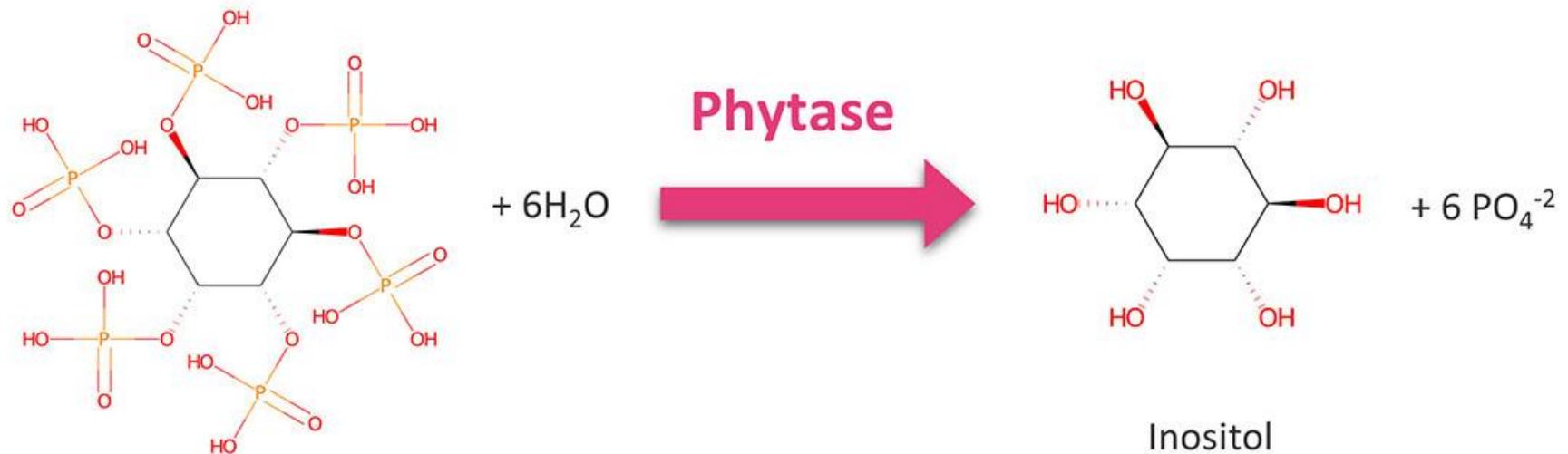


Phytate P content in feed ingredients

Ingredients	Total P (g/kg)	Phytate P (g/kg)	Phytate P as % of total P
Maize	2.7	2.4	89
Wheat	3.5	2.7	77
Oats	3.7	2.9	78
Sorghum	3.5	2.4	69
Barley	4.0	2.7	68
Soybean	6.8	3.9	57
Rapeseed meal	11.9	7.0	59
Sunflower meal	11.6	8.9	77
Chickpeas	4.4	2.1	48
Field peas	4.4	2.4	55

Dietary phosphorus supply

- Dietary supplementation with inorganic P
 - *Non-utilised phytate P still pollutes*
- Dietary supplementation with phytase (myo-inositol hexaphosphate phosphohydrolases), enzyme that can hydrolyse the ester bonds between the phosphate groups and the inositol ring in phytates
 - *Can apply matrix value*



Phytate

Inositol



Exogenous enzymes

Application of dietary enzymes to improve nutrient value of diets is a common approach in poultry nutrition

Supplementation of phytase and xylanase is estimated to equate to savings of 10 kg of inorganic phosphorus (**non-renewable resource mined from the Earth**) per tonne of feed

This is likely to reduce phosphorus pollution by up to 30% and to reduce nitrogen losses to the environment by 5% per kilogram weight gain of broiler chickens



Background

In broiler nutrition, research has shown that “superdoses” of PHY (i.e., >1500 U/kg) can markedly improve feed efficiency, particularly when birds are fed diets deficient in calcium (Ca) and available P (Walk et al., 2013)

Subsequent studies demonstrated that such elevated PHY inclusion levels can lead to nearly complete phytate degradation, increased inositol (IN) concentrations in the gizzard, and improvements in growth performance, including feed efficiency (Walk et al., 2014)

Interestingly, these benefits occurred without substantial changes in bone mineralisation: tibia ash in broilers fed superdosed PHY did not exceed values obtained with mineral-adequate or Ca- and P-supplemented diets



Background

These findings suggest that the performance enhancements associated with PHY superdosing may stem from phytate destruction and subsequent IN release rather than solely from increased Ca and P supply

Despite the recognised benefits of PHY, responses vary depending on factors such as dosage, diet formulation, feeding duration, PHY source, and bird species

Bedford and Rodehutschord (2024) highlighted that exogenous PHY can yield different outcomes in chickens versus turkeys

Background

From a practical standpoint, determining the most profitable PHY dosing strategy requires understanding the capacity of a given PHY product to release P and its economic relationship with inorganic P sources (Wealleans et al., 2016)

However, information on PHY superdosing in turkey diets remains limited

In particular, the effects of very high PHY doses on phytate degradation in low-P turkey diets are poorly understood

Objective

To investigate the impact of very high levels of exogenous PHY (Quantum[®] Blue, ABVista) on energy utilisation, nutrient availability, and phytate degradation in young turkeys fed low-P diets

Growth performance variables were also evaluated



Experimental design (diets)

Main ingredients (g/kg)	PC	NC
Wheat	525.1	527.1
Soybean meal	295.0	295.0
Maize gluten meal	25.0	25.0
.....		
Limestone flour	10.0	17.5
Dicalcium phosphate	30.0	20.5
.....		
Total Ca	17.0	14.4
Total P	10.8	5.3

NC; NC+100 FTU; NC+1000 FTU; NC+10000 FTU; NC+100000 FTU

Experimental design (PHY activity)

Treatments	Expected PHY FTU/kg	Analysed PHY FTU/kg
1	0	< 50
2	0	< 50
3	100	< 50
4	1000	1130
5	10000	14100
6	100000	132000

Experimental design (housing)

Seventy-two 68d old female BUT Premium turkey poults were randomly allocated to 36 raised-floor pens

Each of the six diets was fed to six raised floor pens following randomisation (two birds per pen; floor space 0.36 m²)

Each pen contained a nipple drinker and a trough feeder, with unrestricted access to feed and water

The experiment ended when the birds were 77d old, lasting 9d in total



Experimental design (collection)

Excreta were collected for four days, from 73 to 77d age, and dietary AMEn and nutrient retention coefficients were determined using indigestible marker technique (titanium dioxide)

Growth performance variables were also determined from 68 to 77d age

Inositol phosphate isomers and inositol in excreta were determined by HPLC (Madsen et al., 2019)



Statistical analysis

The data were analysed using the general ANOVA procedure incorporating orthogonal polynomial contrasts to evaluate linear and quadratic trends associated with increasing PHY levels

Additionally, the PC and NC were compared with a single contrast comparison test

Prior to ANOVA, data were examined for homogeneity of variances and normality of residuals. Differences were considered statistically significant at $P < 0.05$. All data are presented as means together with their pooled standard errors of the means (SEMs)

Daily growth performance, AMEn and nutrient retention coefficients

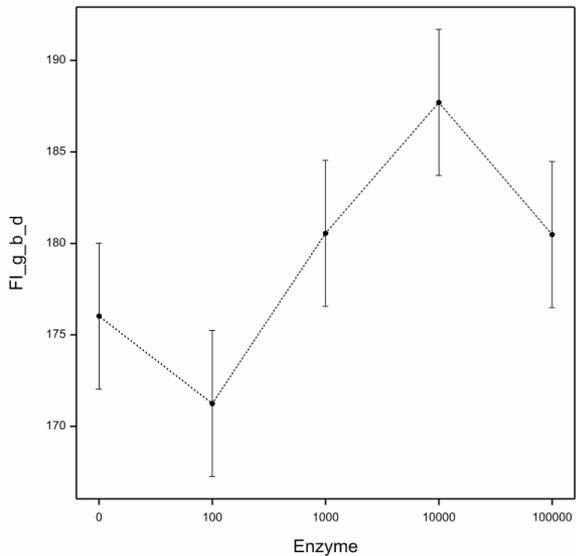
	FI	WG	FCR	AMEn	AMEn:GE	DMR	FR	NR
	(g/b/d)	(g/b/d)		(MJ/kg DM)				
PC (0 FTU)	192	113	1.706	13.46	0.755	0.691	0.865	0.512
NC (0 FTU)	176	96	1.861	13.00	0.721	0.651	0.843	0.483
NC (100 FTU)	171	98	1.772	13.09	0.725	0.653	0.856	0.506
NC (1000 FTU)	181	104	1.751	13.52	0.749	0.689	0.866	0.554
NC (10000 FTU)	188	109	1.727	13.65	0.756	0.699	0.864	0.562
NC (100000 FTU)	181	118	1.527	13.73	0.761	0.707	0.862	0.589
SEM	4.0	3.7	0.0710	0.122	0.0068	0.0090	0.0076	0.0127
P value								
PC vs NC	0.003	0.008	0.165	0.032	0.011	0.026	0.019	0.160
PHY	0.090	0.002	0.043	< 0.001	< 0.001	< 0.001	0.238	< 0.001
L	0.058	< 0.001	0.005	< 0.001	< 0.001	< 0.001	0.072	< 0.001
Q	0.642	0.355	0.409	0.519	0.519	0.709	0.144	0.524
D	0.103	0.965	0.556	0.409	0.409	0.277	0.953	0.523

FTU = phytase concentration in kg diet; FI = daily feed intake per bird; WG = daily weight gain per bird; FCR = feed conversion ratio; AMEn = nitrogen corrected apparent metabolizable energy; AMEn:GE = ratio between AMEn and gross energy (GE); DMR = coefficient of dry matter retention; FR = coefficient of fat retention; NR = coefficient of nitrogen retention; PC = positive control; NC = negative control; PHY = phytase; SEM = standard error of the mean; L = orthogonal polynomial contrast for linear response; Q = orthogonal polynomial contrast for quadratic response; D (deviation) = orthogonal polynomial contrast for deviation from linearity.

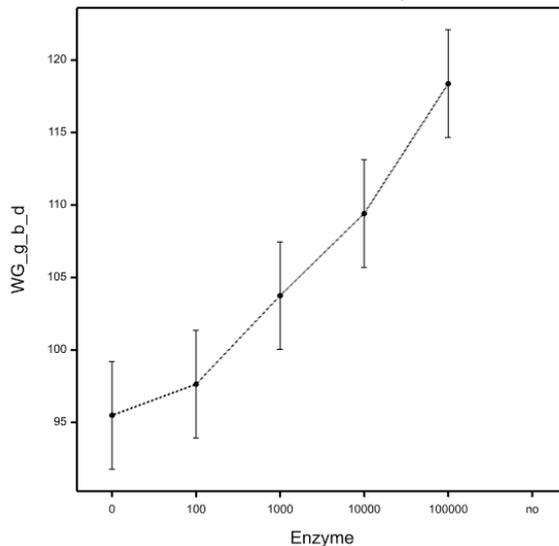


Daily growth performance, AMEn and nutrient retention coefficients

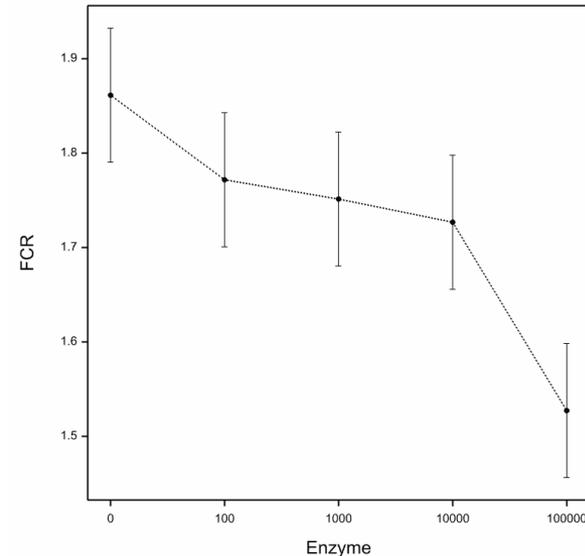
Means \pm e.s.e.'s for Enzyme



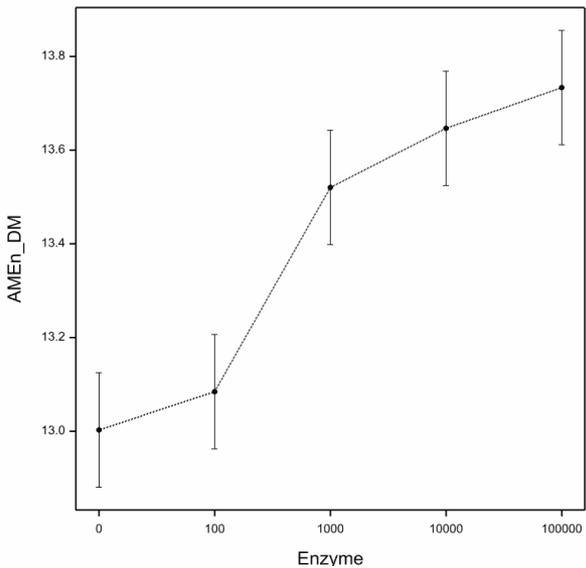
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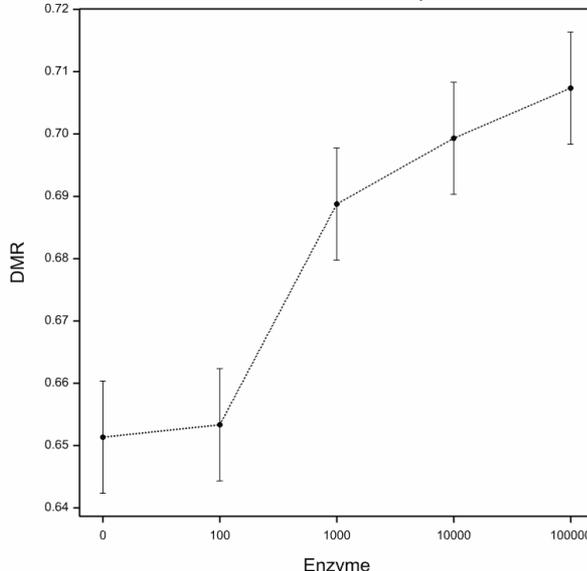
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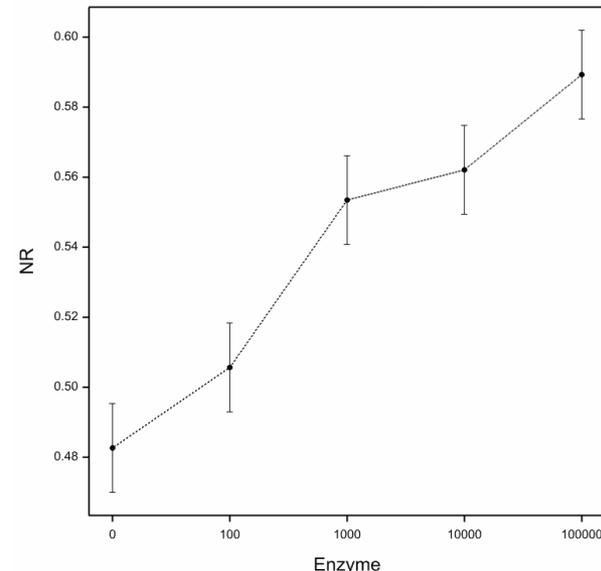
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Dietary impact on inositol phosphate isomers (nmol/g) in excreta

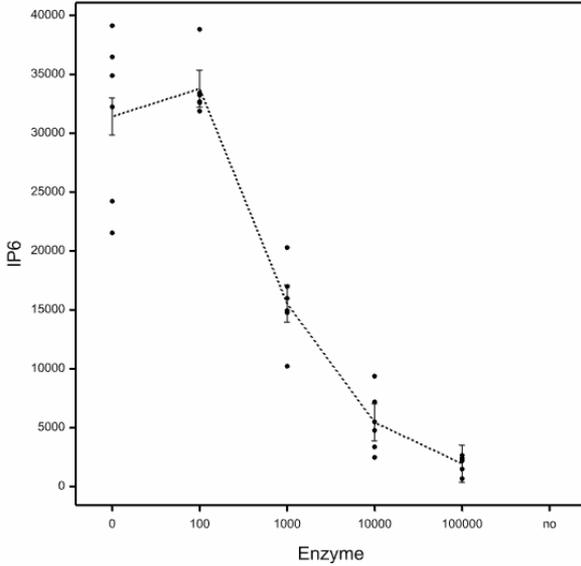
	IP3	IP4	IP5	IP6	IN
PC (0 FTU)	2458	4990	7077	35337	94990
NC (0 FTU)	1884	3630	6018	31423	69838
NC (100 FTU)	2347	5487	7397	33776	56533
NC (1000 FTU)	4632	11762	4481	15534	68132
NC (10000 FTU)	1792	2223	634	5446	80160
NC (100000 FTU)	550	408	212	1943	77481
SEM	188.8	542.6	395.7	1577.3	4935.2
P value					
PC vs NC	0.097	0.084	0.257	0.299	0.056
PHY	< 0.001	< 0.001	< 0.001	< 0.001	0.025
L	< 0.001	< 0.001	< 0.001	< 0.001	0.022
Q	< 0.001	< 0.001	0.006	0.553	0.254
D	< 0.001	< 0.001	< 0.001	< 0.001	0.060

FTU = phytase concentration in kg diet; IP3-6 = inositol phosphate esters; IN = inositol; PC = positive control; NC = negative control; PHY = phytase; SEM = standard error of the mean; L = orthogonal polynomial contrast for linear response; Q = orthogonal polynomial contrast for quadratic response; D (deviation) = orthogonal polynomial contrast for deviation from linearity.

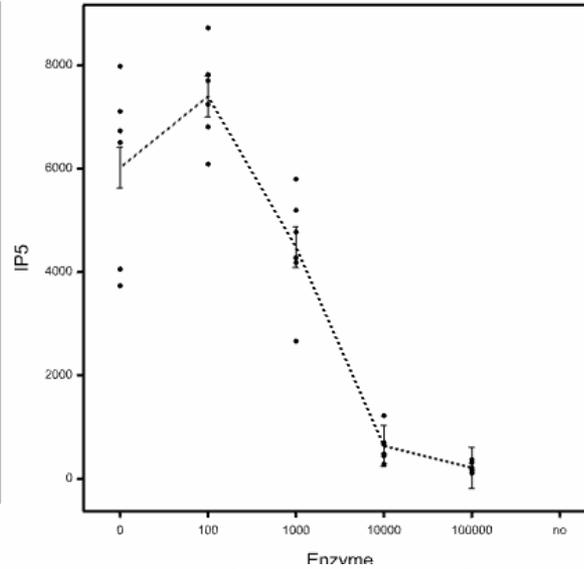


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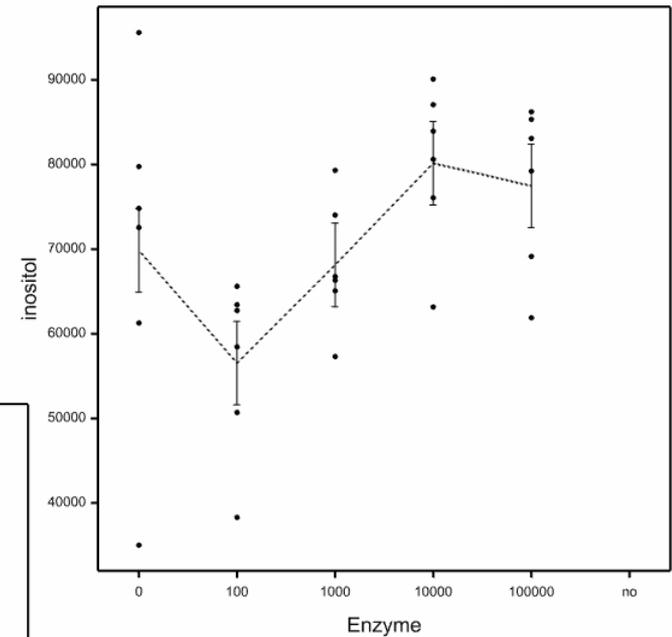
Data & means \pm e.s.e.'s for Enzyme



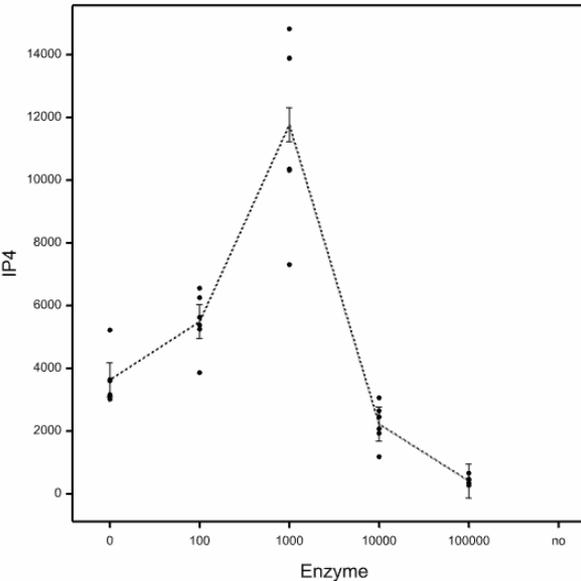
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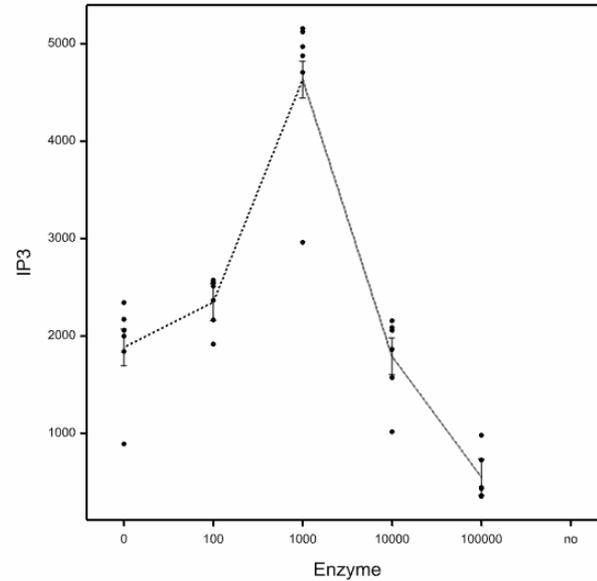
Data & means \pm e.s.e.'s for Enzyme



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Dietary impact on mineral retention coefficients

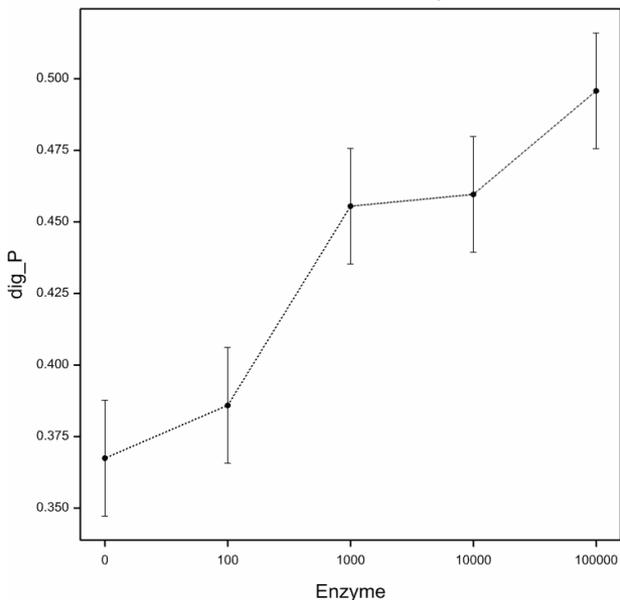
	CaR	MgR	FeR	KaR	MnR	ZnR	PR
PC (0 FTU)	0.439	0.265	0.341	0.207	0.384	0.154	0.413
NC (0 FTU)	0.256	0.095	0.176	0.061	0.116	0.010	0.368
NC (100 FTU)	0.243	0.125	0.179	0.083	0.117	0.080	0.386
NC (1000 FTU)	0.329	0.169	0.232	0.144	0.187	0.088	0.456
NC (10000 FTU)	0.360	0.247	0.262	0.190	0.238	0.164	0.460
NC (100000 FTU)	0.384	0.239	0.283	0.233	0.260	0.156	0.496
SEM	0.0326	0.0211	0.0236	0.0212	0.0250	0.0361	0.0202
P value							
PC vs NC	< 0.001	0.001	0.002	0.005	< 0.001	0.006	0.156
PHY	< 0.001	< 0.001	0.004	< 0.001	< 0.001	0.003	< 0.001
L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Q	0.822	0.530	0.665	0.754	0.628	0.989	0.696
D	0.220	0.219	0.233	0.767	0.158	0.621	0.444

FTU = phytase concentration in kg diet; CaR = coefficient of calcium retention; MgR = coefficient of magnesium retention; FeR = coefficient of iron retention; KaR = coefficient of potassium retention; MnR = coefficient of manganese retention; ZnR = coefficient of zinc retention; PR = coefficient of phosphorus retention; PC = positive control; NC = negative control; PHY = phytase; SEM = standard error of the mean; L = orthogonal polynomial contrast for linear response; Q = orthogonal polynomial contrast for quadratic response; D (deviation) = orthogonal polynomial contrast for deviation from linearity.

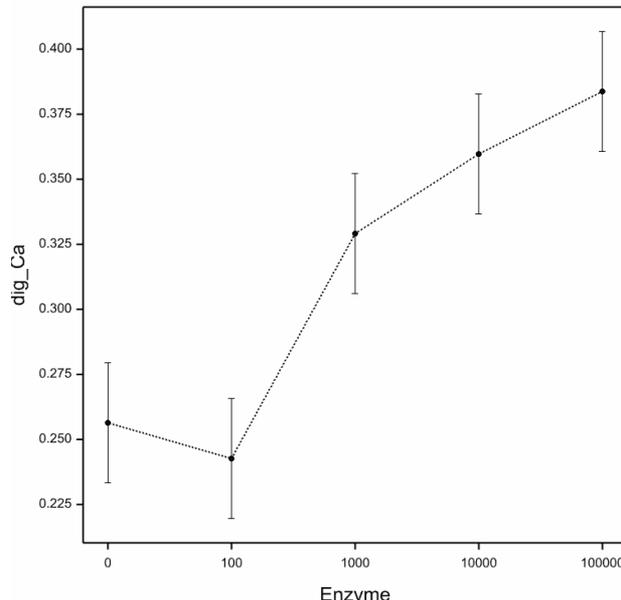


Dietary impact on mineral retention coefficients

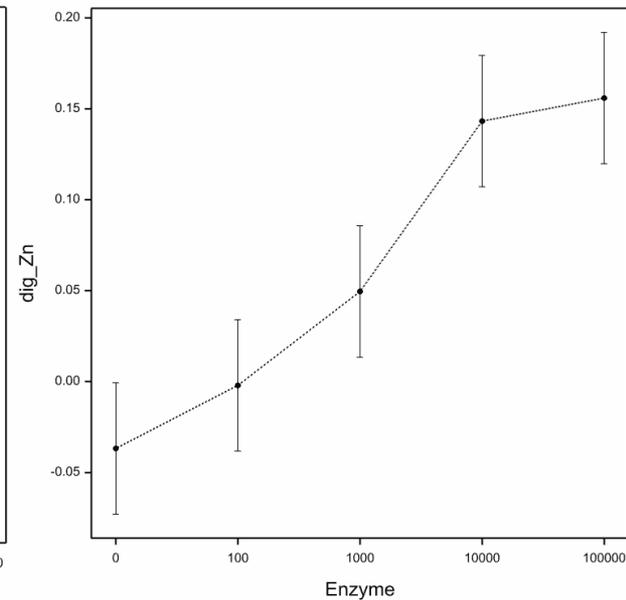
Means \pm e.s.e.'s for Enzyme



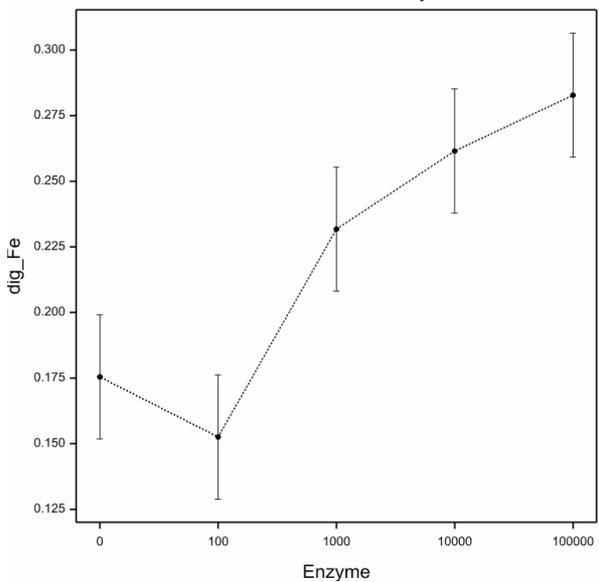
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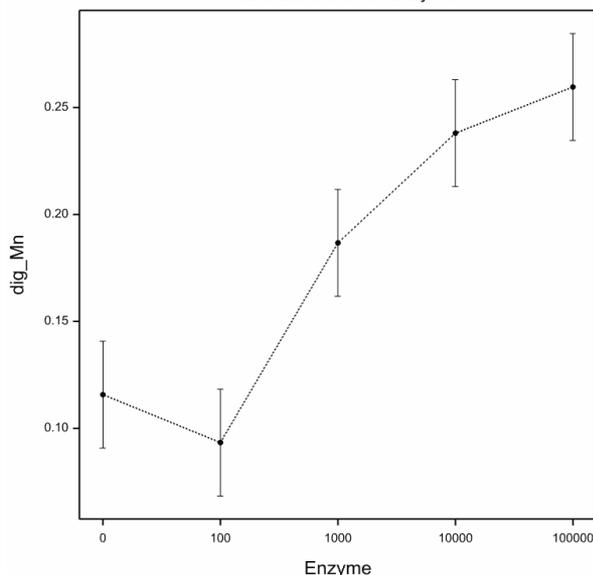
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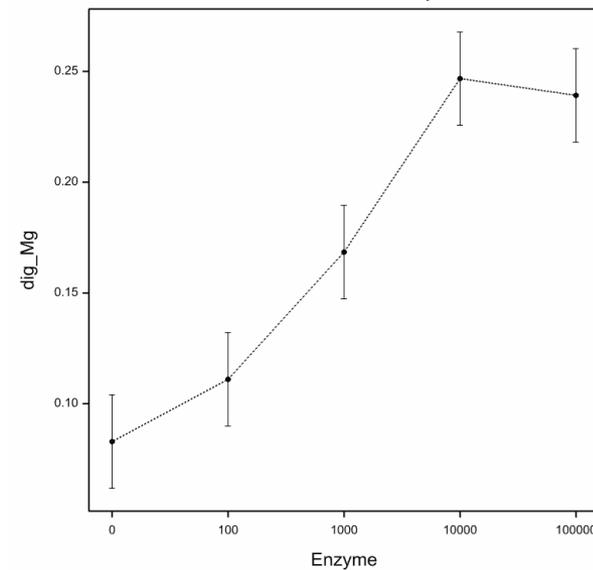
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Discussion

Birds fed the NC exhibited impaired growth performance and reduced energy and nutrient retention (Bassi et al. 2021)

Superdosing of PHY enhances nutrient and energy availability in turkeys fed low P diets (Lee et al. 2017)

The linear improvement in AME, growth and mineral availability with increasing PHY dose further suggest that the PHY facilitated progressive liberation of phytate-bound nutrients

The lack of quadratic component to those variables suggests that the optimum PHY dose could still be higher than tested here

Discussion

The 100 000 FTU/kg reduced IP5-IP6 by 95-96% and IP3-IP4 by 71% and 89% in excreta

From 10 000 to 100 000 FTU all IP isomers decreased by 69%

The IP3-IP6 isomers are highly potent chelators of minerals and may therefore reduce retention of nutrients

The Mg and first order transition metals such as Zn, Cu and Fe are critical for the maintenance of the immune system

The IP isomers may also inhibit gastrointestinal tract enzymes secretion and therefore nutrient digestion, thus further explaining the linear improvement in AMEn, WG and FCR with increased PHY level



Conclusions

This work confirms the response to PHY does not reach an asymptote in turkeys and that broiler data is likely not applicable in superdosed turkeys

The present data also indicate that very high superdoses (>10 000 FTU/kg) provide additional benefit beyond 1000 FTU/kg, particularly with respect to growth performance, and that megadosing (>100 000 FTU/kg) may even be warranted for turkeys

These findings contribute valuable new evidence toward defining optimal PHY dosing strategies for turkey nutrition and support the potential for PHY to reduce reliance on inorganic phosphorus sources in commercial turkey production



