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Age-related changes in mineral retention and excretion in starter and finisher pigs diets with and without exogenous phytase

G. Ganhev[1], S. Chonova[1] , D. Kankov[2], P. Petkov[2], I. Nikifov[2]

[1]Department of Nutrition, Faculty of Agriculture, Trakia University, 6000 Stara Zagora, Bulgaria
[2]Department of Internal Non-infectious Diseases, Department of General and Clinical Pathology, Faculty of Veterinary Medicine, Trakia University, 6000 Stara Zagora, Bulgaria

Abstract.

Male castrated DanBred hybrid pigs were subjected to five balanced feeding experiments designed to assess changes in nitrogen, phosphorus, and calcium consumption as a function of age. Optiphos and Natuphos, two commercially available phytase preparations, were used at a concentration of 0.01%. There was a statistically significant increase ($P<0.05$) in both the quantity of nitrogen consumed by the body and the amount of nitrogen excreted in urine as individuals aged. Additionally, the overall nitrogen production was greater. Over time, there was a marked decline in nitrogen retention. This trend persisted even after phytase was added to the diet. Feeding phytase increased phosphorus uptake by 28% to 34% while decreasing total production by 38% to 45%. As pigs aged, their indigestibility of calcium reduced and their feces production increased. When comparing the effects of Optiphos and Natuphos, no statistically significant difference was found.

Keywords: phytase, age effect, digestibility, nitrogen balance, nitrogen retention, phosphorous, pigs

Introduction

Nutritional supplementation with microbial phytase improves phosphorus and mineral consumption in monogastric animals by increasing hydrolysis of phytates (Jongbloed et al., 1992; Ketaren et al., 1993a,b; Fan et al., 2005). The utilization of phytase leads to improved phosphorus and calcium digestibility and retention in fattening pigs, as well as decreased phosphorus and calcium output in feces, as reported in various studies (Cromwell et al., 1993; Mroz et al., 1994; Schone et al., 1995; Ketaren et al., 1993b; Mroz et al., 1994; Kemme et al., 1999b). Few studies have examined the effects of supplementing with microbial phytase across the various fattening phases, and the findings that have been published are inconsistent. Researchers have shown that supplementing pigs with phytase had the greatest impact on their ability to use phytin phosphorus during the early stages of their development (Cromwell et al., 1993; Hoppe et al., 1993; Young et al., 1993; Pallauf et al., 1994; urination and poops). There was a 5-day prep time and an additional 5-day testing period for each experiment. Table 1 shows the genotype and age-appropriate compound feeds used for the pigs' feeding. The initial groups (controls) did not have phytase added to their diets during any of the three phases of raising (starter, grower, finisher). Exogenous phytase Optiphos was added to the meals of the second group at a concentration of 0.01%, while Natuphos was added to the diets of the third group at the same concentration.
Ibrishimov et al. (1974) determined the calcium and phosphorus levels, whereas the Kjeldahl technique (BDS- ISO) measured the nitrogen content of food and excrement. Ca and P levels in urine were measured using commercial diagnostic kits made by Chema

Material and methods

On the Experimental Farm of the Faculty of Agriculture at Trakia University, five balanced feeding experiments were conducted with castrated males subsequently. This pattern persisted even after phytase

was added to the diet.
In all three tests, the minerals that were investigated exhibited consistent age patterns (Tables 3, 4, and 5). We discovered that as people become older, their nitrogen intake, nitrogen production in urine, and total nitrogen output all go up. There was no difference in the daily nitrogen uptake.

Table 1. Ingredients' content and nutritive value of used compound feeds.

Periods	Starter			Grower			Finisher		
Ingredients, %	Control	Optiphos	Natuphos	Control	Optiphos	Natuphos	Control	Optiphos	Natuphos
Corn	28.58	30.33	30.14	25.28	27.03	26.90	18.63	21.94	21.92
Wheat	30.00	30.00	30.00	30.00	30.00	30.00	18.00	18.00	18.00
Barley	10.00	10.00	10.00	10.00	10.00	10.00	40.00	40.00	40.00
Soybean meal	18.50	18.20	18.20	14.20	14.00	14.00	7.00	6.00	6.00
Sunflower meal	3.70	3.70	3.70	7.00	7.00	7.00	6.00	6.00	6.00
Wheat bran	-	-	-	7.00	7.00	7.00	5.00	4.00	4.00
Fish meal	3.70	3.70	3.70	-	-	-	-	-	-
Sunflower oil	1.90	1.20	1.30	3.20	2.40	2.50	2.60	1.80	1.80
Lysine	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.04	0.04	0.04	0.05	0.03	0.04	0.03	0.03	0.03
Threonine	0.15	0.14	0.15	0.11	0.11	0.10	0.07	0.08	0.08
Salt	0.33	0.33	0.33	0.28	0.28	0.28	0.24	0.24	0.24
Limestone	1.10	1.33	1.40	0.68	0.97	1.00	0.90	1.00	1.00
Dicalcium phosphate	1.20	0.22	0.23	1.40	0.37	0.37	0.73	0.10	0.12
Vitamin premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Phytase*	-	0.01	0.01	-	0.01	0.01	-	0.01	0.01
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.00
1 kg compound feed contains									
ME MJ/kg	13.5	13.5	13.5	13.2	13.2	13.2	13.0	13.0	13.0
CP %	18.34	18.61	18.52	16.46	16.73	16.63	14.06	14.30	14.20
CF %	2.9	2.9	2.9	4.3	4.3	4.3	4.7	4.6	4.6
Total amino acids, %									
Lysine	1.10	1.10	1.10	0.93	0.93	0.93	0.76	0.75	0.75
Methionine	0.33	0.33	0.33	0.29	0.29	0.29	0.25	0.25	0.25
Methionine +Cystin	0.66	0.67	0.67	0.62	0.62	0.62	0.53	0.54	0.54
Threonine	0.73	0.74	0.73	0.62	0.61	0.60	0.49	0.49	0.49
Tryptophan	0.40	0.41	0.41	0.36	0.37	0.37	0.27	0.29	0.29
Digestble amino acids, %									
Lysine	0.97	0.97	0.97	0.81	0.81	0.81	0.65	0.65	0.65
Methionine	0.29	0.29	0.29	0.26	0.26	0.26	0.22	0.22	0.22
Methionine +Cystin	0.57	0.57	0.58	0.53	0.53	0.53	0.46	0.46	0.46
Threonine	0.61	0.61	0.61	0.50	0.50	0.50	0.41	0.40	0.40
Tryptophan	0.29	0.29	0.30	0.27	0.27	0.27	0.21	0.22	0.22
Ca %	0.77	0.77	0.77	0.67	0.67	0.67	0.60	0.60	0.60

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P total %	0.68	0.51	0.51	0.66	0.49	0.49	0.53	0.41	0.41
P available %	0.33	0.34	0.33	0.27	0.28	0.27	0.21	0.25	0.25
Na %	0.18	0.18	0.18	0.14	0.14	0.14	0.13	0.13	0.13

* Phytase was supplemented to the diet of pigs according to the experimental design. In group II, the preparation Optiphos 5000 (Huvepharma, Peshtera, Bulgaria) was used, whereas in group III - Natuphos 5000 (BASF, Ludwigshafen, Germany).

Table 2. Feed and water intake and amounts of excreted faeces and urine by animals during the feed balance trials.

Groups/parameters	Periods		
	Starter (n = 3)	Grower (n = 6)	Finisher (n = 6)
	x̄ ± Sx̄	x̄ ± Sx̄	x̄ ± Sx̄
Group I No phytase			
Feed intake, kg/day	2.26±0.03^{a}	2.65±0.04^{a}	3.07±0.04^{a}
Water intake, l /day	3.96±0.22^{ab}	6.19±0.26^{a}	5.87±0.34^{b}
Faeces, kg/day	1.10±0.07^{a}	1.54±0.09	1.79±0.16^{a}
Urine, l/day	1.89±0.05	2.69±0.34	2.98±0.50
Group II Methionine +Cystin)			
Feed intake, kg/day	2.11±0.10^{a}	2.51±0.06^{a}	3.16±0.09^{a}
Water intake, l /day	4.50±0.77^{a}	6.86±0.65^{a}	5.78±0.35
Faeces, kg/day	1.05±0.14^{a}	1.40±0.10^{b}	1.82±0.16^{ab}
Urine, l/day	1.61±0.25^{ab}	3.23±0.20^{a}	2.98±0.41^{b}
Group III With Natuphos)			
Feed intake, kg/day	2.18±0.04^{a}	2.58±0.09^{a}	3.03±0.08^{a}
Water intake, l /day	4.49±0.44	5.46±0.48	5.34±0.63
Faeces, kg/day	1.16±0.06^{a}	1.45±0.13	1.63±0.13^{a}
Urine, l/day	2.24±0.29	2.53±0.22	2.79±0.35
Average for all groups	(n = 9)	(n = 18)	(n = 18)
Feed intake, kg/day	2.19±0.04^{a}	2.58±0.04^{a}	3.09±0.04^{a}
Water intake, l /day	4.32±0.28^{a}	6.17±0.30^{a}	5.66±0.26^{a}
Faeces, kg/day	1.10±0.05^{ab}	1.46±0.06^{a}	1.74±0.08^{b}
Urine, l/day	1.91±0.14^{ab}	2.82±0.16^{a}	2.90±0.23^{b}

a,b – equal letters designate statistically significant differences

with age, but its retention decreased gradually from starter to finisher. The supplementation of compound feeds with phytases did not have any effect on these events. Data for phosphorus balance in the three groups of pigs showed that the intake of this mineral increased with age. This increase was higher in control groups, where the necessary phosphorus is supplied by the dicalcium phosphate included in rations. In experimental animals, one part of phosphorus is expected to comes from degradation of phytates by introduced enzyme preparations, and therefore the total phosphorus intake was lower as compared to controls. The phosphorus output in faeces increase slightly with age, but the output in urine did not change consistently. The supplementation of phytase reduced statistically significantly (P< 0,05) the phosphorus output in pigs from experimental groups. The utilization of phytase preparations increased considerably the digestibility and absorption of phosphorus, but there were no significant age-related difference in

Table 3. Nitrogen, phosphorus and calcium balance in the group of pigs non-supplemented with phytase

Parameters	Periods		
	Starter (n = 3)	Grower (n = 6)	Finisher (n = 6)
	x̄ ± Sx̄	x̄ ± Sx̄	x̄ ± Sx̄
Nitrogen			
Intake, g/day	58.62±2.96[a]	62.33±1.20	65.83±2.09[a]
Fecal, g/day	9.99±0.68	9.70±0.46	11.06±0.68
Urinary, g/day	23.31±1.09[a]	26.50±0.97[b]	29.41±0.87[ab]
Absorbed, g/day	48.63±2.31	52.63±1.95	54.77±2.56
Total excreted, g/day	33.30±1.77[a]	36.21±0.66[b]	40.46±1.15[ab]
Digestibility, %	82.98±0.47	84.37±0.92	83.24±0.75
Retened. g/day	25.32±1.44	26.12±0.70	25.37±1.05
Retention, %	43.19±1.08[a]	41.89±0.52[b]	38.48±0.65[ab]
Phosphorus			
Intake, g/day	15.31±0.13	19.21±1.22	18.27±1.08
Fecal, g/day	9.00±0.26	11.15±0.78	10.95±0.64
Urinary, g/day	0.84±0.12	0.62±0.18[a]	1.16±0.15[a]
Absorbed, g/day	6.31±0.34	8.06±0.38	7.32±0.33
Total excreted, g/day	9.84±0.16	11.77±0.88	12.11±0.76
Digestibility, %	41.16±1.98	41.98±1.41	40.09±0.29
Retened, g/day	5.46±0.21[a]	7.44±0.44[ab]	6.16±0.34[b]
Retention, %	35.68±1.20	38.92±1.34[a]	33.82±0.60[a]
Calcium			
Intake, g/day	18.26±0.30	22.40±1.97	21.27±1.48
Fecal, g/day	7.21±0.39[ab]	12.72±1.04[a]	13.67±0.92[b]
Urinary, g/day	0.44±0.05	0.75±0.13[a]	0.39±0.05[a]
Absorbed, g/day	11.05±0.23	9.68±0.21	7.60±0.45
Total excreted, g/day	7.65±0.34[ab]	13.46±1.16[a]	14.06±0.94[b]
Digestibility, %	60.57±1.65[a]	42.87±1.82[a]	35.58±1.37[a]
Retened, g/day	10.61±0.18[a]	8.94±0.92	7.21±0.66[a]
Retention, %	58.13±1.32[a]	39.66±1.83[a]	33.73±1.47[a]

a,b – equal letters designate statistically significant differences

on this front. Based on the data on calcium balance, it was found that finisher rations had higher amounts of calcium consumed and output increased with age, but digestibility decreased due to significantly higher feed intake during fattening periods, regardless of the presence or absence of phytase sources. An individual's

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total compound feeds and urine nitrogen production. There was a statistically significant decrease in calcium retention and an increase in nitrogen emission with increasing age. The years. Phytase supplementation did not significantly change this leads to increased nitrogen excretion for a variety of reasons, the most frequent of which are decreased absorption and lower digestion. Table 6 shows the consolidated statistics over the whole fattening time.The results of the current studies indicated that digestibility remained constant with age, even if the grower's nitrogen content was lower, and that nitrogen retention (g/day) was almost

Table 4 shows the equilibrium of nitrogen, phosphorus, and calcium in the Optiphos-supplemented pig group.

Table 6. Summarized data for nitrogen, phosphorus and calcium balance in relation to the growth stage of pigs

Parameters	Periods		
	Starter (n = 3)	Grower (n = 6)	Finisher (n = 6)
	x̄ ± Sx̄	x̄ ± Sx̄	x̄ ± Sx̄
Nitrogen			
Intake, g/day	56.62±1.32[a]	60.81±1.07[b]	66.01±1.47[ab]
Fecal, g/day	9.79±0.31	9.45±0.23[a]	10.61±0.44[a]
Urinary, g/day	21.25±0.68[a]	25.19±0.65[a]	29.38±0.74[a]
Absorbed, g/day	46.83±1.32	51.36±2.07	55.40±2.56
Total excreted, g/day	31.05±0.93[a]	34.64±0.64[a]	40.00±0.85[a]
Digestibility, %	82.72±0.25	84.40±0.43	83.95±0.52
Retened, g/day	25.58±0.64	26.18±0.52	26.01±0.64
Retention, %	45.20±0.75[a]	43.04±0.35[a]	39.39±0.34[a]
Phosphorus			
Intake, g/day	12.37±0.75[ab]	15.48±0.87[a]	15.15±0.71[b]
Fecal, g/day	6.28±0.69	7.67±0.67	8.06±0.57
Urinary, g/day	0.91±0.14	0.75±0.12	0.83±0.10
Absorbed, g/day	6.09±0.28	7.81±0.25	7.09±0.29
Total excreted, g/day	7.18±0.69	8.43±0.68	8.89±0.64
Digestibility, %	50.37±2.39	51.40±1.82	47.64±1.43
Retened, g/day	5.19±0.15[a]	7.05±0.33[a]	6.26±0.18[a]
Retention, %	42.86±2.17	46.38±1.65	42.26±1.56
Calcium			
Intake, g/day	17.54±0.33[ab]	21.70±1.16[a]	21.43±0.94[b]
Fecal, g/day	6.46±0.25a	11.31±0.62[a]	12.99±0.56[a]
Urinary, g/day	0.44±0.04[a]	0.80±0.07[ab]	0.50±0.05[b]
Absorbed, g/day	11.08±0.26	10.39±0.31	8.44±0.22
Total excreted, g/day	6.89±0.24[ab]	12.11±0.67[a]	13.49±0.57[b]
Digestibility, %	63.24±1.03[a]	47.54±1.33[a]	39.19±0.98[a]
Retened, g/day	10.65±0.21[a]	9.59±0.63b	7.95±0.44[ab]
Retention, %	60.75±0.95[a]	43.89±1.34[a]	36.88±0.93[a]

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Conclusion

Pigs' nitrogen consumption and excretion in urine both rose sharply with age. Additionally, the overall nitrogen production was greater. There was a significant decline in nitrogen retention as people became older. This trend persisted even after phytase was added to the diet. There was a 40-60% phosphorous production in the excrement. At this stage

was unaffected by the passage of time. By including phytase, the absorption of phosphorus was enhanced by 28-34% while its total production was decreased by 38-45%. There was a significant decrease in environmental pollutants as a result of this. There is an inverse relationship between age with the digestion of calcium and its excretion in feces. Between the starter and finisher periods, there was a decline in the retention of this mineral. The two phytases utilized in these studies, Optiphos and Natuphos, did not show any statistically significant difference in their effects.

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