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EFFECT OF PHOSPHORUS SUPPLY ON PHOSPHORUS RETENTION IN WEANLING PIGLETS

DJELOVANJE OPSKRLJIVANJA FOSFOROM NA RETENCIJU FOSFORA U ODBIJENE PRASADI

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Original scientific paper – Izvorni znanstveni clanak
UDC: 636.4:636.084.11.085.12.
Received – primljeno: 19. september – rujan 1997.

ABSTRACT

An essential condition for the smooth development of young animals is a supply of macro- and microelements set in accordance with the intensity of growth. The macroelements of greatest significance with respect to animal nutrition are calcium and phosphorus, the latter being the more critical in relation to environmental protection. The objective of these investigations was to determine how the digestibility and retention of phosphorus in weaned piglets change in the first half of the rearing period (from days 28 to 58) when diets based on maize, barley and soya are fed, giving an increasing calcium and phosphorus supply but a constant Ca:P ratio. These investigations were performed using KAHYB barrows weaned at 28 days; 5 piglets were subjected to each treatment, with 2 replications (n=10). The experimental diets were formulated taking into account the nutrient recommendations of the ARC (1981). Seven treatments were applied in the study. The first treatment diet contained exclusively native phosphorus, while in treatments II, III, IV, V, VI and VII the diets used also contained an inorganic phosphorus supplement, the quantity of which increased in increments of 1 g phosphorus per kg diet from treatment II to treatment VII. In all treatments the Ca:P ratio was 1.2:1. The experimental data were analysed by means of variance analysis. The data obtained indicate that phosphorus digestibility increased up to the level of 7.9 g/kg total dietary phosphorus content, while phosphorus retention rose only much as 5.9 g/kg total phosphorus content. On the basis of these results it can be recommended that the phosphorus content of diets for weaned piglets reared under intensive conditions be set at 3.6 g/kg digestible phosphorus content in the first half of the rearing period (days 28 to 58).

Key words: Weaned piglet, Dietary phosphorus, Phosphorus digestibility, Phosphorus retention.

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INTRODUCTION

Endeavours to determine the precise phosphorus requirements of pigs are fully justified by the need both to meet more precisely the requirements of animals of high genetic capacity and to respond to environmental concerns.

Phosphorus requirement values stated in most nutrient recommendations presently in use are higher, and are given in terms of total phosphorus. According to the majority of researchers involved in mineral supply to pigs these values could be decreased without any detrimental effect to the performance of the livestock. Phosphorus pollution arising from animal production can be traced not only to excessive supplementation of diets with inorganic phosphorus but also to the low digestibility of the phosphorus content of the various types of grain forming the basis of feeds. The phosphorus requirements of livestock could be met with more precision if digestible phosphorus content, rather than total phosphorus content, were used in the calculation involved in the formulation of diets. The preconditions for the determination and fulfilment of phosphorus requirements on the basis of digestible phosphorus are that there should be available reliable data on requirement values stated in terms of digestible phosphorus and that there be a sufficiently comprehensive database containing the digestible phosphorus content values for the components of livestock diets.

Through these studies the authors sought to determine how the digestibility and retention of phosphorus changes in weaned piglets in the first half of the rearing period (days 28 to 58) when diets based on maize, barley and soya of increasing levels of phosphorus supply but with identical Ca:P ration are fed.

MATERIAL AND METHOD

Five KAHYB barrows weaned at 28 days were used in the experiments; 2 replications were performed (n=10). The live weight of the piglets at the beginning of the trials was 9.0 ± 0.8 kg.

The experimental diets were formulated on the basis of maize, barley and soya, taking into account the nutrient recommendations of the ARC (1981). The composition and nutrient content of the basal diet fed in the course of the trials is shown in table 1. Seven treatments were applied in the investigations. The diet fed in the first treatment contained no inorganic phosphorus supplement. For the diets used in the other treatments the diets were supplemented with inorganic phosphorus, increased in increments of 1 g phosphorus per kg diet at each stage from treatment II to treatment VII. The ratio of calcium to phosphorus in all the diets was identical, at 1.2:1. The diet was given to the experimental animals ad libitum. The digestibility trials consisted of a 9-day adaptation period and a 5-day collection period. Feed intake during the ad libitum feeding was recorded daily, accurate to 1 gramme. Faeces were collected in a polyethylene bag attached to the anus of each piglet, while the urine produced was collected in a closed urine collection receptacle attached to a urine collection tray. Samples of the diets, faeces and urine were subjected to chemical analysis in accordance with the appropriate Hungarian Standard (MSz-6830-77-81) and variance analysis (ANOVA, SAS, 1990) was carried out on the experimental data obtained. In the cases of significant treatment efects the statistical reliability of the differences was checked by means of the Tukey test (SAS, 1990).

Table 1. Composition and nutrient content of the basal diet (g/kg)

Tablica 1. Sastav i hranjiva vrijednost osnovnog obroka (g/kg)

Composition – Sadržaj	
Maize – kukuruz	470.9
Barley – Ječam	250.0
Extr. soybean meal – Sojina sačma	258.0
Others[a] – Ostalo	21.1
Total – Ukupno	1000.0
Nutrient content – Hranjive tvari	
Dry matter – Suha tvar	881.7
Crude protein – Sirove bjelančevine	180.7
DEs (MJ/kg)[b]	13.6
Lysine[b]	13.3
Methionine + cystine[b]	6.7
Calcium – kalcij	4.8
Phosphorus – fosfor	3.9

a : mineral, amino acid and vitamin supplement – dodaci minerala, aminokiselina i vitamina

b : calculated value – kalkulirane vrijednosti

RESULTS AND DISCUSSION

The digestibility of the phosphorus content of the diets is summarised in table 2. The data obtained show that the lowest phosphorus digestibility was measured for the first treatment. This low digestibility (43.2%) accompanied by a relatively high level of faecal excretion of phosphorus can be explained by the low digestibility of the phosphorus content of the maize/soya bean-based diets. In treatment II, which contained 1 g/kg inorganic phosphorus, the leval of faecal excretion of phosphorus was approximately the same, which indicates that when phosphorus supply is suboptimal the phosphorus content of monocalcium phosphate is digested very efficiently. The phosphorus digestibility measured in the case of the diet containing no inorganic phosphorus supplement (43.2%) was exceeded by 9.7% by that measured for treatment II ($P \leq 0.05$). The phosphorus digestibility of 52.9% measured for treatment II indicates that weaned piglets are capable of absorbing over 90% of the phosphorus content of monocalcium phosphate. Düngelhoef (1994) reported similar data on the basis of trials carried out in young pigs. The data published by that author indicate that 91% of the phosphorus content of monocalcium phosphate is absorbed under conditions of restricted phosphorus supply.

In the studies reported in the present paper, phosphorus digestibility increased significantly ($P \leq 0.05$) up to the fifth treatment (i.e., to 7.9 g/kg total phosphorus content). When the phosphorus content of a diet is further increased, it is to be anticipated that the intensity of absorption will decrease. The degree of this was measured at 65.6% in treatment VI (8.9 g/kg total phosphorus content) and 64.5% in treatment VII (9.9 g/kg total phosphorus content). Presumably this decreasing intensity of absorption can be explained by decline in absorption capacity and by the fact that in these two treatments the quantity of available phosphorus was substantially in excess of the requirements of the experimental animals.

Table 2. Digestibility and retention of the phosphorus content of the diets (%)
Tablica 2. Probavljivost i retencija sadržaja fosfora u hrani (%)

Treatments Postupci	Parameters			
	P-digestibility P-probavljivost		P-retention P-retencija	
	$\bar{x}$	sd	$\bar{x}$	sd
I.	43.2^{a}	2.6	40.3^{a}	2.9
II.	52.9^{b}	2.7	50.5^{b}	3.1
III.	61.8^{c}	3.6	$55.0^{b,c}$	3.4
IV.	63.7^{c}	1.9	$52.0^{b,c,d}$	4.0
V.	67.9^{e}	1.5	$54.4^{c,d}$	3.1
VI.	$65.6^{c,e}$	3.6	48.0^{d}	3.7
VII.	$64.5^{c,d,e}$	2.8	46.7^{d}	2.6

^{a,b,c,d,e} $P \leq 0.05$

Table 3. Phosphorus balance in the animals
Tablica 3. Ravnoteza fosfora u životinja

Treatments Postupci	Parameters - Parametri							
	P-intake P-unos		Faecal excretion Fekalno izlučivanje		Urinary excretion Izlučivanje urinom		P-retention P-retencija	
	($mg/kg^{0.75}/d$)		($mg/kg^{0.75}/d$)		($mg/kg^{0.75}/d$)		($mg/kg^{0.75}/d$)	
	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
I.	369.7^{a}	41.9	209.8^{a}	23.9	9.9^{a}	1.5	149.6^{a}	22.3
II.	457.7^{a}	58.1	214.9^{ab}	25.9	9.0^{a}	2.3	231.4^{b}	34.4
III.	616.5^{b}	75.1	227.0^{ab}	24.3	42.4^{b}	5.6	349.0^{c}	42.0
IV.	716.1^{b}	99.0	256.5^{bc}	27.7	82.0^{c}	10.3	$369.2^{c,d}$	28.4
V.	871.7^{c}	109.2	284.6^{cd}	32.6	98.8^{c}	15.2	438.4^{e}	32.3
VI.	942.8^{c}	74.7	320.0^{d}	19.5	175.0^{d}	25.4	$466.0^{e,f}$	33.5
VII.	1035.7^{d}	105.0	379.1^{e}	38.1	191.0^{d}	20.4	499.2^{f}	30.0

a,b,c,d,e,f: $P \leq 0.05$

Changes in the level of urinary phosphorus excretion are presented in table 3. The experimental data obtained indicate that only minimal quantities of phosphorus were excreted in the urine in treatments I and II (3.9 and 4.9 g/kg total phosphorus content respectively). These quantities (9.9 and 9.0 mg/kg$^{0.75}$/d respectively) can presumably be regarded as chiefly of endogenous origin. On further increase of the phosphorus content of the diet renal phosphorus excretion rises, indicating that there is a considerable surplus of phosphorus available to the animals. The level of this in treatment III (5.9 g/kg total phosphorus content) was measured at 42.4 mg/kg$^{0.75}$/d; this value doubled by treatment VI ($P \leq 0.05$).

In the subsequent treatments (IV, V, VI and VII) urinary phosphorus excretion was observed to increase further, reaching 18.4% of the quantity of phosphorus ingested for the two diets with the highest phosphorus content. On examining changes in phosphorus retention it was obseved that, in comparison with the quantity of phosphorus ingested, retention increased significantly ($P \leq 0.05$) only up to the third treatment (5.9 g/kg total phosphorus content), stabilising at a level of 52.0-54.4% for treatments IV and V and decreasing in the case of the two diets with the highest phosphorus content. In the first treatment, in which the diet contained only native phosphorus, 1.1 g phosphorus was retained daily by the experimental animals; this represents 149.7 mg when related to 1 kg metabolic body weight. This quantity is practically equivalent to that of the phosphorus absorbed, and in this study resulted in 40.3% phosphorus retention. Since in the case of the third treatment (5.9 g/kg total phosphorus content) urinary phosphorus excretion increased exponentially, it can be assumed that at this level the quantity of phosphorus required for maintenance and weight gain in weaned piglets reared under intensive conditions had already been reached. In this treatment the weaned piglets, at a mean body weight of 13.9 kg, retained 2.4 g phosphorus daily, which can be provided by a total dietary phosphorus content of 5.9 g/kg, or 3.6 g/kg digestible phosphorus content.

This quantity is equivalent to a utilisable phosphorus content of 3.2 g/kg, which in turn corresponds to the recommendation of the NRC (1988); however, in this recommendation it is also suggested that, in conditions of 29.6% amino acid supply lower than that recommended by the ARC (1981) the phosphorus requirement of weaned piglets can be met by means of the quantity of phosphorus given above.

On the basis of the experimental results obtained it can be stated that in weaned piglets (from days 28 to 58) phosphorus digestibility increases up to the level of 7.9 g/kg total dietary phosphorus content, while phosphorus retention in relation to intake increases only as much as 5.9 g/kg total dietary phosphorus. Based on these results it can be recommended that the phosphorus content of diets for weaned piglets reared under intensive conditions be set at 3.6 g/kg digestible phosphorus content in the first half of the rearing period (from days 28 to 58).

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SAŽETAK

Bitan uvjet za normalan razvoj mladih životinja je opskrbljivanje makro- I mikroelementima u skladu s intenzitetom rasta. Najvažniji makroelementi u svezi s hranidbom životinja su kalcij I fosfor; fosfor je opasniji u svezi sa

zaštitom okoliša. Cilj je ovih istraživanja bio odrediti kako se probavljivost i zadržavanje (retencija) fosfora u odbijene prasadi mijenja u prvoj polovici uzgoja (od 28. do 58. dana života) kada se obroci temelje na kukuruzu, ječmu i soji, čime se povećava unošenje kalcija i fosfora, ali je omjer Ca:P postojan. Ova su istraživanja obavljena na KAHYB leglu/skupini praščića odbijenih 28. dana; 5 je praščića podvrgnuto svakom od postupaka s dva ponavljanja (n=10). Pokusni obroci sastavljeni su na temelju hranidbenih preporuka ARC (1981). U pokusu je primijenjeno 7 postupaka. Obroci u prvom postupku sadržavali su samo fosfor u hrani, dok su obroci u II., III., IV., V., VI. i VII. postupku sadržavali i dodatak anorganskog fosfora čija se količina povečavala za 1 g fosfora na 1 kg obroka od II. do VII. postupka. U svim postupcima omjer Ca:P bio je 1,2 : 1. Podaci iz pokusa analizirani su analizom varijance. Dobiveni podaci pokazuju da se probavljivost fosfora povečavala do 7,9 g/kg ukupnog sadržaja fosfora u hrani, dok je retencija fosfora porasla samo do 5,9 g/kg ukupnog sadržaja fosfora. Na temelju ovih rezultata može se preporučiti da se sadržaj fosfora u hrani odbijene prasadi u intenzivnom uzgoju odredi na 3,6 g/kg sadržaja probavljivog fosfora u prvoj polovici uzgojnog razdoblja (od 28. do 58. dana).

Ključne riječi: odbijena prasad, fosfor u hrani, probavljivost fosfora, retencija fosfora