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Bioavailability of Phosphorus in Selected Feedstuffs for Pigs

Kuen-Chan Huang and Gary L. Allee

Summary

We used 140 crossbred pigs averaging 30.4 lb to determine phosphorus bioavailability with the slope-ratio technique. A standard curve was established by feeding a basal diet 0% inorganic phosphorus and three levels of $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ (.056% P, .112% P, and .168% P). The response curve of test ingredients was established with basal diet data and feeding three levels of each test ingredient. The test ingredient was incorporated at the expense of dextrose. The relative phosphorus bioavailability values were: 51% for wheat, 23% for milo, 35% for oats, 29% for corn, 36% for soybean meal, 42% for cottonseed meal, 93% for meat and bone meal, and 102% for dicalcium phosphate.

Introduction

Many scientists use the rule that nonruminants use one-third of the phosphorus in plant materials, since about 30% of phosphorus in plant materials is nonphytate phosphorus. Recent research here and at the University of Kentucky and University of Illinois, indicates that available phosphorus from plant ingredients may be lower. Because most swine feed ingredients are from the plant kingdom, it is important to evaluate the availability of phosphorus from these ingredients.

Procedures

One hundred and forty crossbred pigs averaging 30.4 lb were randomly allotted by weight and sex to 5' x 5' pens containing 5 pigs each. Pens were randomly assigned to treatments. Pigs had free access to feed and water throughout the experiment. Composition of the basal diet is presented in Table 23. After 35 days on trial, pigs were killed, their front legs removed and meat and connective tissue were manually removed from the bones, then the tibia and fibia were separated. Tibias were used in determining breaking force. The force required to break the bone on the middle of the lateral surface of the tibia was determined with a Riehle F. S. 20 testing machine.

Tibia breaking force (an average value in kg from 5 pigs) was used as a function of phosphorus intake (an average of 5 pigs, g/day). A standard curve was constructed from feeding the basal diet and three levels .056%, .112%, and .168% added phosphorus from $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$. The curve of test ingredient was established using the basal diet data and three levels of each test ingredient. Test ingredients were incorporated at the expense of dextrose. Dividing the slope of the test ingredient response curve by the slope of the standard curve and multiplying by 100 gave relative phosphorus bioavailability.

Results and Discussion

Using the slope-ratio technique relative phosphorus bioavailability values were: 51% for wheat, 25% for milo, 29% for corn, 36% for oats, 36% soybean meal, 42% for cottonseed meal, 102% for dicalcium phosphate, and 93% for meat and bone meal. Present results and previous findings are shown in Table 24.

Wheat had the highest phosphorus bioavailability of the plant ingredients tested, which may stem from its increased phytase activity. It is assumed that enzyme phytase hydrolyzes phytate to phosphoric acid in the gastrointestinal tract, and that the ingredient's nonphytate phosphorus is associated with phosphorus availability.

Dicalcium phosphate was equal in availability to monosodium phosphate because each contain the same ortho-phosphate ($-PO_4$), the metabolic form of phosphorus in animal systems. Meat and bone meal has a high available phosphorus (93%) since the phosphorus in meat and bone meal is in the non-phytate form.

Table 23. Composition of the Basal Diet^a

Ingredient	Percent
Dextrose	62.70
Soybean meal	34.00
Salt	0.50
Vitamin premix	1.00
Trace mineral premix	0.05
Antibiotic	0.25
Limestone	1.50
	100.00

^a16.1% crude protein, 0.64% calcium, 0.23% phosphorus

Table 24. Relative Bioavailability (%) of Phosphorus in Selected Feedstuffs

Slope-ratio studies	Species	corn	wheat	milo	oats	soybean meal	cottonseed meal
Univ. of Kentucky (1977)	pig ^a	16	51	--	--	18	--
Univ. of Kentucky (1979)	chick ^a	12	51	--	--	--	--
Univ. of Kentucky (1979)	pig ^a	9.9	--	--	--	0	--
Kansas State Univ. (1979)	pig ^a	--	--	19	--	--	--
Kansas State Univ. (1979)	chick ^b	19	48	25	--	28	--
Univ. of Kentucky (1980)	pig ^a	--	40	--	23	17	0
Kansas State Univ. (1980)	pig ^a	29	51	25	36	36	42

^aBased on slope-ratio of bone breaking strength with monosodium phosphate or monopotassium phosphate as the standard.

^bBased on slope-ratio of bone ash with monosodium phosphate as the standard.