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EVALUATION OF MODIFIED POTATO STARCH IN DIETS FOR THE EARLY-WEANED PIG[1]

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Summary

Two growth trials were conducted to compare the effectiveness of replacing either corn or lactose with modified potato starches in diets for conventionally and early-weaned pigs. In Exp. 1, 198 pigs (initially 9.4 lb and 19 d of age) were used to determine if modified potato starch (potato starch 1) can replace a portion of the lactose in a high nutrient dense diet. Pigs were allotted by weight, gender, and ancestry to each of six dietary treatments with either five or six pigs per pen and six pens per treatment. The control diet contained 10% dried whey (7.2% lactose), 7.5% spray-dried porcine plasma, 2.5% select menhaden fish meal, and 1.75% spray-dried blood meal. Additional treatments were formulated by adding 7 or 14% modified potato starch or lactose in place of corn. A positive control diet also was formulated containing 29% dried whey (providing the same amount of lactose as the 10% dried whey plus 14% lactose diet). All diets were formulated to contain 1.5% lysine, and .90% Ca, .80% P, and 17.88% soybean meal and were fed in a meal form. From day 0 to 14 postweaning, increasing dietary lactose tended to linearly improve ADG and ADFI. Added potato starch did not improve ADG compared with pigs fed the control diet, but ADFI increased linearly with increasing potato starch. In Exp. 2, 180 pigs (8.5 lb and 14 d of age) were used to evaluate the effects of two modified potato starches (potato starch 1 or potato starch 2,a further hydrolyzed potato starch with a greater percentage of sugars as either glucose or maltose as a replacement for either corn or lactose in a segregated early-weaning diet (SEW). Pigs were fed a control diet containing 15% dried whey, 12% added lactose, 6% porcine plasma, and 6% select menhaden fish meal. Modified potato starch 1 or 2 (12%) replaced either corn or the added lactose on an equal weight basis. From d 0 to 7 postweaning, pigs fed the modified potato starch 1 had greater ADG and ADFI than those fed modified potato starch 2. Pigs fed diets with either starch substituted for corn had greater ADG than those fed diets with either starch substituted for lactose. From d 0 to 14 and d 0 to 21, pigs fed diets containing either modified potato starch substituted for corn tended to have greater ADG than those fed the control diet. This appeared to be the result of greater feed intake of pigs fed the diets containing either starch substituted for corn compared with those fed the control diet or diets containing either starch substituted for lactose. Pigs fed diets with either modified starch substituted for lactose had similar ADG as those fed the control diet. In conclusion, these results suggest that potato starch can improve growth performance of pigs when substituted for corn and can replace a portion of the lactose in an SEW diet without adversely affecting performance.

Introduction

Previous research (KSU Swine Day Report of Progress 641, p 63) has indicated that modified potato starch substituted for

[1]The authors would like to thank Avebe America, Inc. for donating the modified starches used in these experiments.

corn in a Phase I diet increased ADG and ADFI of pigs weaned at 21 d of age. The modified potato starch used in this previous trial was treated enzymatically to break the carbohydrate molecules into individual glucose molecules and spray-dried. It had a dextrose equivalent (relative sweetness compared with pure dextrose) of 20. Unfortunately, the positive influence on growth performance of this modified starch is overshadowed by its hydroscopic nature and difficulties in flowing through feed handling systems. In addition, at this time, modified starches are not likely to be cost competitive as a replacement for corn. Therefore, the objective of these experiments was to evaluate the use of modified starches as replacements for either corn or lactose in diets for conventionally and segregated early-weaned pigs.

Procedures

A total of 198 pigs (initially 9.4 lb and 19 d of age) was used in a 35-d growth trial. Pigs were allotted by weight and ancestry to one of six dietary treatments for a total of five to six pigs per pen and six pens per treatment. The trial was divided into two phases. Experimental diets were fed during Phase I (d 0 to 14 postweaning). All pigs were fed a common Phase II diet from d 14 to 35 postweaning.

Dietary treatments were based on level of lactose plus casein or modified potato starch 1 plus casein added to the Phase I diet in replacement of dietary corn. Potato starch 1 was enzymatically hydrolyzed to contain approximately 1.5% glucose, 4.5% maltose, and 8.5% maltotriose, with the remaining 85.5% sugars as higher glucose polymers. It had a dextrose equivalent of 20. The control diet was soybean meal-based containing 10% dried whey, 1.75% spray-dried blood meal, 2.5% fish meal, and 7.5% spray-dried porcine plasma. Lactose (7 or 14%) and potato starch 1 (7 or 14%) replaced corn in the control diet. The sixth treatment was a positive control diet with 29% dried whey. This diet contained the same amount of lactose as the diet containing 14% added lactose and 10% dried whey. All Phase I diets were formulated to 1.5% lysine, .42% methionine, .9% calcium, and .8% phosphorus. The common Phase II diet contained 10% dried whey and 2.5% spray-dried blood meal. It was formulated to contain 1.25% lysine, .36% methionine, .9% calcium, and .8% phosphorus. Both Phase I and Phase II diets were fed in a meal form.

In Exp. 2, a total of 180 pigs (initially 8.5 lb and 14 d of age) was used in a 21-d growth trial. Pigs were allotted by sex, weight, and ancestry and placed in pens containing six pigs each. Pens were assigned randomly to one of five treatments in a randomized complete block design. Pigs were fed the five experimental diets from d 0 to 21 postweaning. All diets were formulated to contain 1.7% lysine, .48% methionine, .90% Ca, and .80% P. The control diet contained 10% spray-dried porcine plasma, 1.75% spray-dried blood meal, and 15% dried whey. Modified potato starch 1 (same as in Exp. 1) or a further modified potato starch (potato starch 2) replaced 12% of either corn or lactose to provide the four additional treatments. Potato starch 2 was obtained by enzymatic hydrolysis to provide 3% glucose, 10% maltose, 12.5% maltotriose, with the remaining 74.5% of sugars as higher glucose polymers. It has a dextrose equivalent of 30. All diets were fed in a pelleted form.

In both experiments, pigs were housed in an environmentally controlled nursery with slotted-metal flooring and were allowed ad libitum access to feed and water. Pigs were weighed and feed disappearance was measured weekly to determine ADG, ADFI, and F/G.

Results and Discussion

Experiment 1. From d 0 to 14 postweaning, increasing dietary lactose tended to improve (linear, $P<.11$) ADG and ADFI. Added potato starch 1 did not improve ADG compared with pigs fed the control diet, but ADFI increased (linear, $P<.05$) with increasing added starch. Pigs fed the diet containing 29% dried whey had the greatest ADG, which was not different from that of

pigs fed the diet containing 14% added lactose. However, pigs fed the diet containing 29% dried whey had greater ADG ($P<.05$) than those fed 14% added potato starch. No differences occurred in ADG of pigs fed the 10% dried whey control diet compared with pigs fed the diets with added starch or with 7% added lactose. Feed efficiency was not affected by dietary treatment. During Phase II when pigs were fed a common diet, no differences were observed in ADG. Pigs fed the diet containing 29% dried whey had greater ADFI than those fed the diet containing 14% added starch during Phase I. However, pigs previously fed diets containing added starch tended to have improved F/G (linear, $P<.11$) compared with those pigs fed the diet containing 10% dried whey. Overall results (d 0 to 35) showed improved ADG (linear, $P<.05$) and ADFI (quadratic, $P<.10$) with increasing lactose fed during Phase I, but no linear improvement with added starch. However, the mean ADG of pigs fed diets containing added starch during Phase I was greater than that of pigs fed the control diet ($P<.05$). Pigs fed the diet containing 29% dried whey had greater ADFI compared with those fed the diet with 14% added starch. In summary, ADG and ADFI increased with increasing lactose from 7.2 to 21% of the diet. Although no differences occurred in growth performance of pigs fed 29% dried whey (21% lactose) and those fed 14% added lactose (21% total lactose), pigs fed the 29% dried whey diet tended to have better ADG and F/G. Pigs fed 14% added starch had decreased ADG compared with those fed 29% dried whey, suggesting that modified starch is not a complete replacement for lactose in starter diets for pigs weaned at 21 d of age.

Experiment 2. From d 0 to 7 postweaning, pigs fed the diets containing modified potato starch 1 had greater ADG and ADFI ($P<.10$) than those fed diets containing modified potato starch 2. Pigs fed diets with either starch substituted for corn had greater ADG ($P<.05$) than those fed diets with starch substituted for lactose. In addition, pigs fed the diet containing either modified starch substituted for corn had greater ADG compared with pigs fed the control diet ($P<.05$). From d 0 to 14 and d 0 to 21, pigs fed diets containing either modified starch substituted for corn tended to have greater ADG ($P<.10$) and ADFI ($P<.05$) than those fed the control diet. Pigs fed diets with starch substituted for corn had greater ADFI than those fed diets containing starch substituted for lactose ($P<.05$). Pigs fed modified potato starch 1 had greater ADFI and improved F/G than those fed modified potato starch 2 ($P<.10$). Pigs fed diets with either starch substituted for lactose had similar ADG to those fed the control diet. Therefore, substituting modified starches for corn improves ADG and ADFI of early-weaned pigs, with the greatest benefits observed for pigs fed modified potato starch 1.

These results suggest that modified potato starch can improve growth performance of pigs when substituted for corn and can replace a portion of the lactose in an SEW diet without adversely affecting performance. However, currently, the hydroscopic nature of modified potato starch prohibits regular application in starter pig diets, because it causes major problems in manufacturing and feed handling.

Table 1. Diet Composition (Exp. 1)[a]

Item	10% Dried whey	Lactose, %		Potato starch, %		29% Dried whey	Phase II[b]
		7%	14%	7%	14%		
Corn	53.25	45.67	38.06	45.67	38.06	35.05	58.76
Soybean meal (46.5% CP)	17.88	17.88	17.88	17.88	17.88	17.88	21.26
Potato starch 1	--	--	--	7.00	14.00	--	--
Lactose	--	7.00	14.00	--	--	--	--
Dried whey	10.00	10.00	10.00	10.00	10.00	29.00	10.00
Spray dried plasma	7.50	7.50	7.50	7.50	7.50	7.50	--
Soy oil	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Fish meal menhaden	2.50	2.50	2.50	2.50	2.50	2.50	--
Spray-dried blood meal	1.75	1.75	1.75	1.75	1.75	1.75	2.5
Monocalcium phosphate (21% P)	1.77	1.84	1.92	1.84	1.92	1.32	1.97
Antibiotic[c]	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Casein	--	.55	1.16	.55	1.16	--	--
Limestone	.61	.57	.53	.57	.53	.41	.83
KSU vitamin premix	.25	.25	.25	.25	.25	.25	.25
KSU trace minerals	.15	.15	.15	.15	.15	.15	.15
Methionine	.104	.103	.100	.103	.100	.100	.05
Copper sulfate	.075	.075	.075	.075	.075	.075	.075
L-lysine HCL	.150	.128	.103	.128	.103	--	.15
Total	100	100	100	100	100	100	100

[a]Diet was formulated to contain 1.5% lysine, .44% methionine, .9% Ca, and .8% P and was fed from d 0 to 7 postweaning.

[b]Diet was formulated to contain 1.25% lysine, .35% methionine, .9% Ca, and .8% P and was fed from d 7 to 1 postweaning.

[c]Provided 150 g/ton apramycin in Phase I and 50 g/ton carbadox in Phase II.

Table 2. Diet Composition (Exp. 2)[a]

Item	Control	Potato starch substituted for	
		Corn	Lactose
Corn	30.54	18.33	30.53
Soybean meal (46.5% CP)	14.97	14.97	14.97
Potato starch 1 or 2	--	12.00	12.00
Lactose	12.00	12.00	--
Dried whey	15.00	15.00	15.00
Spray-dried plasma protein	10.00	10.00	10.00
Soy oil	6.00	6.00	6.00
Menhaden fish meal	6.00	6.00	6.00
Spray-dried blood meal	1.75	1.75	1.75
Monocalcium phosphate (21% P)	1.47	1.65	1.48
Antibiotic[b]	1.00	1.00	1.00
Zinc oxide	.38	.38	.38
Limestone	.21	.14	.21
KSU vitamin premix	.25	.25	.25
KSU trace minerals	.15	.15	.15
DL-methionine	.12	.15	.12
Isoleucine	--	.043	--
L-lysine HCL	--	.035	--
Salt	.15	.15	.15
Total	100	100	100

[a]Diets were formulated to contain 1.7% lysine, .48% methionine, and .90% Ca, and .8% P and fed from d 0 to 21 postweaning.
[b]Provided 150 g/ton carbadox.

Table 3. Effect of Added Potato Starch or Lactose on Starter Pig Performance (Exp. 1)[a]

Item	10% Dried whey	Potato starch, %		Lactose, %		29% Dried whey	CV
		7%	14%	7%	14%		
D 0 to 14							
ADG, lb[bc]	.64	.66	.67	.67	.71	.77	13.2
ADFI, lb[de]	.92	1.02	1.05	1.02	1.07	1.13	9.1
G/F	1.47	1.54	1.57	1.50	1.52	1.45	10.8
D 14 to 35							
ADG, lb	1.08	1.15	1.15	1.19	1.15	1.16	7.3
ADFI, lb[f]	2.10	2.13	2.08	2.17	2.12	2.21	6.2
G/F[g]	1.95	1.85	1.81	1.83	1.83	1.9	7.0
D 0 to35							
ADG, lb[b]	.90	.96	.96	.98	.98	1.00	6.6
ADFI, lb[cdh]	1.62	1.69	1.67	1.71	1.69	1.78	5.5
G/F	1.82	1.76	1.74	1.75	1.72	1.76	6.7

[a]One hundred ninety eight weanling pigs were used (initially 9.41 lb and 19 d of age +/- 3 d of age), with 5 pigs per pen in three reps and 6 pigs per pen in three reps. Day 0 to 14 diets were formulated to contain 1.5% lysine, .42% methionine, .9% Ca, and .8% P. Day 14 to 35 diets contained 1.5% lysine.
[bd]Linear effect of lactose ($P<.11$ and $P<.05$), respectively.
[cf]14% starch vs 29% dried whey ($P<.05$ and $P<.11$), respectively.
[eg]Linear effect of starch ($P<.05$ and $P<.11$), respectively.
[h]Quadratic effect of lactose ($P<.10$).

Table 4. Effect of Added Potato Starch Substituted for Corn or Lactose on Starter Pig Performance (Exp. 2)[a]

Item	Control	Starch substituted for corn		Starch substituted for lactose		CV
		Potato starch 1	Potato starch 2	Potato starch 1	Potato starch 2	
D 0 to 7						
ADG, lb[bc]	.41	.48	.43	.43	.40	12.8
ADFI, lb[d]	.41	.50	.42	.49	.41	17.1
F/G	1.00	1.03	.94	1.16	1.01	19.0
D 0 to 14						
ADG, lb[e]	.54	.62	.59	.55	.56	11.1
ADFI, lb[dfg]	.62	.73	.67	.71	.59	9.5
F/G[d]	1.15	1.18	1.14	1.30	1.06	11.7
D 0 to 21						
ADG, lb[e]	.67	.74	.72	.68	.70	9.3
ADFI, lb[dfg]	.80	.94	.87	.90	.78	9.8
F/G[d]	1.20	1.27	1.20	1.33	1.12	7.6

[a]One hundred eighty weanling pigs were used (initially 8.6 lb and d of age), 6 pigs/pen, 5 pens per treatment. Experimental diets were fed from d 0 to 21 postweaning.
[bd]Mean of pigs fed MD20 vs SPG ($P<.10$ and $P<.01$), respectively.
[cg]Mean of pigs fed starch substituted for corn vs lactose ($P<.05$ and $P<.10$), respectively.
[ef]Mean of pigs fed starch substituted for corn vs control ($P<.10$ and $P<.05$), respectively.