SUCROSE AND MOLASSES IN SIMPLE OR COMPLEX DIETS FOR NURSERY PIGS

I. Mavromichalis, J. D. Hancock, R. H. Hines, J. M. DeRouchey, B. W. Senne, S. P. Sorrell, and H. Cao

Summary

Three experiments were conducted to determine the effects of replacing lactose with sucrose and molasses in simple and complex diets for nursery pigs. In general, complex diets supported greater growth performance than simple diets, and added lactose and sucrose gave greater efficiency of growth than diets without added sugars. Comparisons among sugar sources indicated that lactose, sucrose, and molasses were utilized equally well by weanling pigs.

(Key Words: Lactose, Sucrose, Molasses, Nursery Pigs.)

Introduction

The efficacy of milk products in diets for nursery pigs is well documented. Also, recent research suggests that a source of highly digestible protein can be mixed with crystalline lactose and used to replace milk products (dried whey and dried skim milk) in weaner diets. However, if price or availability necessitates the replacement of milk products, the same problem usually applies to crystalline lactose.

Sucrose long has been suggested as an energy source and appetite enhancer when used in nursery diets. The same is true for molasses, although high dietary concentrations generally are not recommended. Also, sucrose and cane molasses are readily accessible throughout much of the world. Thus, the experiments reported herein were designed to determine the effects of replacing lactose with sucrose and cane molasses on growth performance and nutrient digestibility in nursery pigs.

Procedures

In the first experiment, 210 (PIC line 326 sire × C15 and C22 dams) weanling pigs with an average initial BW of 10 lb were used in a 30-d growth assay to determine the effects of replacing 50 and 100% (wt/wt) of crystalline lactose with cane sucrose and cane molasses (Carmilglo®). The diets (Table 1) were formulated to 1.7 and 1.5% lysine for d 0 to 10 and 11 to 35, respectively, and were fed in pelleted form.

The pigs were grouped by initial BW and assigned to treatments based on sex and ancestry. There were four pigs per pen in two blocks, five pigs per pen in two blocks, and six pigs per pen in four blocks for a total of eight pens per treatment. The pigs were housed in an environmentally controlled nursery facility with plastic-coated flooring. Each pen (5 ft × 5 ft) was equipped with a five-hole self-feeder and nipple waterer to allow ad libitum consumption of feed and water. Temperature at animal level was at 90°F initially and lowered by 3°F each week thereafter. Pigs and feeders were weighed at initiation and the end of each phase to allow calculation of ADG, ADFI, and F/G.

All data were analyzed as a randomized complete block design using the GLM procedures of SAS. Pen was the experimental unit. Treatment comparisons were made using the orthogonal contrasts: 1) lactose vs other sugars; 2) sucrose vs molasses; 3) 50 vs 100% replacement of lactose; and 4) sucrose vs molasses × 50 vs 100% replacement of lactose.

In our second experiment, a total of 150 nursery pigs (PIC genotype) with an average initial BW of 15 lb was used in a 30-d growth assay. In this experiment, sucrose and molasses were larger percentages of the diet than in Exp. 1 because whey protein concentrate was used in place of dried whey, thus giving more room in the formula for crystalline lactose (20% in Exp. 2 vs 10% in Exp. 1). A negative control, with no added sugar, also was included in Exp. 2 to determine if, indeed, the carbohydrates sources were beneficial to the pigs. The diets (Table 2) were formulated to 1.7 and 1.5 % lysine for d 0 to 10 and 10 to 35, respectively, and fed in pelleted form.

Table 1. Compositions of the Basal Diets for Experiment 1

Item	Phase 1	Phase 2
Ingredient, %		
Corn	26.67	37.33
Soybean meal (46.5% CP)	26.62	38.57
Edible grade whey	20.00	5.00
Lactose[a]	10.00	10.00
Spray-dried porcine plasma	4.00	-
Spray-dried wheat gluten	4.00	-
Spray-dried blood cells	2.00	2.00
Soybean oil	2.00	2.00
Monocalcium phosphate	1.50	1.91
Limestone	.94	1.02
Salt	.10	.20
Vitamin premix	.25	.25
Trace trace mineral premix	.15	.15
Zinc oxide	.39	.39
Lysine HCl	.22	-
DL-methionine	.16	.18
Antibiotic[b]	1.00	1.00
Calculated analysis		
Crude protein ($N \times 6.25$), %	25.7	23.7
Lysine, %		
Ca, %	1.7	1.5
P, %	.9	.9
Digestible energy, kcal/lb	.8	.8
	1,579	1,589

[a]Replaced by 50 and 100% sucrose or molasses.
[b]Provided 75 mg of apramycin per lb of complete diet.

The pigs were grouped by initial BW and assigned to treatments based on sex and ancestry. There were five pigs per pen and five pens per treatment. Pig management was the same as for Exp. 1.

All data were analyzed as a randomized complete block design with the treatment comparisons: 1) no sugar vs other treatments; 2) lactose vs other sugars; 3) sucrose vs molasses; 4) 50 vs 100% replacement of lactose; and 5) sucrose vs molasses × 50 vs 100% replacement of lactose.

In our third experiment, a total of 180 nursery pigs (PIC genetics) with an average initial BW of 14 lb was used in a 30-d growth assay. Treatment main effects were diet complexity (simple and complex) and carbohydrate source (no sugar, lactose, and sucrose) arranged as a 2 × 3 factorial. The diets (Table 3) were formulated to 1.7 and 1.5% lysine for d 0 to 10 and 10 to 35, respectively, and were fed in pelleted form.

The pigs were grouped by initial BW and assigned to treatments based on sex and ancestry. There were six pigs per pen and five pens per treatment. The pigs were housed and managed in the same environmentally controlled nursery facility used in Exps. 1 and 2. On d 10, fecal samples were collected (four pigs per pen) by rectal massage. The fecal samples were pooled within pen, dried, and ground, and concentrations of Cr, DM, and N in the feces and diets were determined.

The data were analyzed as a randomized complete block design with a 2 × 3 factorial arrangement of treatments and pen as the experimental unit. Treatment comparisons were made using the orthogonal contrasts: 1) simple vs complex; 2) no sugar vs sugars; 3) simple vs complex × no sugar vs sugars; 4) lactose vs sucrose; and 5) simple vs complex × lactose vs sucrose.

Results and Discussion

For d 0 to 10 of our first experiment, no differences ($P>.17$) were observed for ADG, ADFI, or F/G when lactose was replaced with either sucrose or molasses (Table 4). Researchers have suggested that increasing diet sweetness, by adding sugars enhances palatability and feed intake postweaning. In our experiment, the diets were of a complex nature and were consumed readily, thus decreasing the likelihood that a "sweetener" would affect feed intake. For d 10 to 30 and overall (d 0 to 30), ADG and ADFI also were not affected by replacing lactose with sucrose or molasses (P>.15), but a trend (P<.10) occurred for slightly better F/G in pigs fed lactose.

Compared to diets with sucrose, those with molasses supported greater overall ADG (P<.02). This was caused primarily by the reduction in performance when 100% of the lactose was replaced with sucrose (sucrose vs molasses × 50 vs 100% replacement, P<.01).

In our second experiment, a negative (no added sugar) control was included in the treatment design, and a higher concentration of dietary lactose, sucrose, and molasses was included in the diets. For d 0 to 10, replacing half or all of the lactose with sucrose and the molasses had no effect on ADG, ADFI, and F/G (P>.35) (Table 5). However, the pigs fed the diet without added carbohydrate sources had growth performance that was similar to pigs fed the more complex diets (P>.33).

For d 10 to 30 and overall (d 0 to 30), added lactose, sucrose, and molasses had no effect (P>.29) on growth performance of the pigs. Comparisons within the added carbohydrate sources indicated a trend (P<.10) for greater overall ADG when sucrose and molasses were used to replace lactose. However, replacing 100% of the lactose with sucrose and molasses reduced F/G for d 10 to 30 (P<.01) and 0 to 30 (P<.04) compared with 50% replacement.

The observation of no negative effect of feeding a diet without dietary simple sugars is in contrast with much published research. Therefore, our pigs, consuming a high-nutrient density diet in relatively high amounts (attributable to the presence of spray-dried porcine plasma, blood meal, and wheat gluten), apparently performed well without highly digestible sources of carbohydrates in their diets.

Our third and final experiment was designed to test the hypothesis that the presence of simple sugars in complex diets may be without benefit (e.g. as in Exp. 2) and to demonstrate the possible effects of easily digested carbohydrates in simple nursery diets. Consuming a complex diet from d 0 to 10 postweaning resulted in greater ADG (P<.01) and ADFI (P<.01) and in a trend (P<.06) for better F/G (Table 6). The F/G was better (P<.04) when sugars were added to the diets, and pigs fed diets with sucrose tended to have better F/G than pigs fed diets with lactose (P<.07).

For the overall period (d 0 to 30), a trend (P<.06) occurred for improved ADG and F/G with complex diets and improved F/G with inclusion of sugars (P<.01). Also, apparent digestibilities of DM (P<.04) and N (P<.05) were greater for the complex versus simple diets. An interaction (P<.03) of diet complexity × sugar additions resulted from better F/G when simple sugars where included in complex diets. Finally, diets with sucrose tended to be used more efficiently (P<.07) than diets with lactose. Also, apparent digestibilities of DM (P<.04) and N (P<.05) were greater for the complex versus simple diets.

Based on our three experiments, complex diets were of great benefit in the period immediately postweaning.

Table 2. Compositions of the Basal Diets for Experiment 2

Item	Phase 1		Phase 2	
	No added sugar	Crystalline lactose	No added sugar	Crystalline lactose
Ingredient, %				
Corn	53.05	28.97	57.23	40.46
Soybean meal (46.5% CP)	21.59	25.62	31.69	34.39
Lactose[a]	-	20.00	-	14.00
Whey protein concentrate (34% CP)	8.00	8.00	2.00	2.00
Spray-dried porcine plasma	4.00	4.00	-	-
Spray-dried wheat gluten	4.00	4.00	-	-
Spray-dried blood cells	2.00	2.00	2.00	2.00
Soybean oil	2.00	2.00	2.00	2.00
Monocalcium phosphate	1.79	1.98	1.50	1.64
Limestone	1.15	1.05	1.08	1.01
Salt	.25	.25	.35	.35
Vitamin premix	.25	.25	.25	.25
Trace mineral premix	.15	.15	.15	.15
Zinc oxide	.39	.39	.26	.26
Lysine HCl	.24	.16	.21	.16
DL-methionine	.14	.18	.20	.23
Threonine	-	-	.08	.10
Antibiotic[b]	1.00	1.00	1.00	1.00
Calculated analysis				
Crude protein (N × 6.25), %	25.7	25.5	22.5	22.3
Lysine, %	1.7	1.7	1.5	1.5
Ca, %	.9	.9	.8	.8
P, %	.8	.8	.7	.7
Digestible energy, kcal/lb	1,591	1,619	1586	1,606

[a]Replaced by 50 and 100% sucrose or molasses.
[b]Provided 75 mg of apramycin per lb of complete diet.

Table 3. Composition of Diets for Experiment 3

	Phase I				Phase 2			
	Simple		Complex		Simple		Complex	
Item	No added sugar	Crystalline lactose	No added sugar	Crystalline lactose	No added sugar	Crystalline lactose	No added sugar	Crystalline lactose
Ingredient, %								
Corn	54.37	29.57	52.80	28.70	60.21	43.28	57.23	40.46
Soybean meal (46.5% CP)	33.36	38.15	21.59	25.62	30.73	33.61	31.69	34.39
Lactose[a]	-	20.00	-	20.00	-	14.00	-	14.00
Whey protein concentrate (34% CP)	-	-	8.00	8.00	-	-	2.00	2.00
Fish meal	5.00	5.00	-	-	2.00	2.00	-	-
Spray-dried porcine plasma	-	-	4.00	4.00	-	-	-	-
Spray-dried wheat gluten	-	-	4.00	4.00	-	-	-	-
Spray-dried blood cells	-	-	2.00	2.00	-	-	2.00	2.00
Soybean oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Monocalcium phosphate	1.37	1.55	1.79	1.98	1.31	1.44	1.50	1.64
Limestone	.75	.65	1.15	1.05	.94	.87	1.08	1.01
Salt	.25	.25	.25	.25	.35	.35	.35	.35
Vitamin premix	.25	.25	.25	.25	.25	.25	.25	.25
Trace mineral premix	.15	.15	.15	.15	.15	.15	.15	.15
Zinc oxide	.39	.39	.39	.39	.26	.26	.26	.26
Lysine HCl	.41	.31	.24	.16	.42	.37	.21	.16
DL-methionine	.26	.29	.14	.18	.22	.25	.20	.23
Threonine	.19	.19	-	-	.16	.17	.08	.10
Chromic oxide[b]	.25	.25	.25	.25	-	-	-	-
Antibiotic[c]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Calculated analysis								
Crude protein (N × 6.25), %	23.9	23.9	25.7	25.5	21.3	21.1	22.5	22.3
Lysine, %	1.7	1.7	1.7	1.7	1.5	1.5	1.5	1.5
Ca, %	.9	.9	.9	.9	.8	.8	.8	.8
P, %	.8	.8	.8	.8	.7	.7	.7	.7
Digestible energy, kcal/lb	1,591	1,619	1,591	1,619	1,584	1,604	1,586	1,606

[a]Replaced with sucrose.
[b]Used as an indigestible marker.
[c]Provided 75 mg of apramycin per lb of complete diet.

Table 4. Effects of Replacing Lactose with Sucrose and a Cane Molasses on Growth Performance in Nursery Pigs (Exp. 1)[a]

		Ingredient Replacing Lactose[b]								
	Crystaline	Sucrose		Molasses			Contrasts[c]			
Item	Lactose	50%	100%	50%	100%	SE	1	2	3	4
Day 0 to 10										
ADG, lb	.65	.67	.65	.66	.71	.02	-[d]	.13	-	.05
ADFI, lb	.62	.63	.64	.65	.70	.02	-	.04	.15	-
F/G	.95	.94	.99	1.00	.98	.07	-	-	-	-
Day 10 to 30										
ADG, lb	1.04	1.03	.93	1.02	1.03	.02	.15	.06	.05	.02
ADFI, lb	1.37	1.42	1.35	1.41	1.44	.03	-	-	-	-
F/G	1.32	1.38	1.46	1.38	1.40	.05	.11	-	-	-
Day 0 to 30										
ADG, lb	.90	.91	.81	.89	.91	.01	-	.02	.03	.01
ADFI, lb	1.11	1.15	1.09	1.15	1.19	.02	-	.11	-	.13
F/G	1.23	1.26	1.34	1.29	1.30	.04	.10	-	-	-

[a]A total of 210 pigs (four to six pigs/pen and eight pens/treatment) with an avg initial BW of 10 lb.
[b]Replaced lactose on a wt/wt basis. All diets contained 20% dried whey, which provided 14% lactose.
[c]Contrasts were: 1) lactose vs other sugars; 2) sucrose vs molasses; 3) 50 vs 100% replacement of lactose; and 4) sucrose vs molasses × 50 vs 100% replacement of lactose.
[d]Dashes indicate P>.15.

Table 5. Effects of Replacing Lactose with Sucrose and a Cane Molasses on Growth Performance in Nursery Pigs (Exp. 2)[a]

			Ingredient Replacing Lactose[b]									
			Sucrose		Molasses			Contrasts[c]				
Item	No Added Sugar	Crystalline Lactose	50%	100%	50%	100%	SE	1	2	3	4	5
Day 0 to 10												
ADG, lb	.76	.76	.81	.81	.77	.81	.04	-[d]	-	-	-	-
ADFI, lb	.88	.81	.89	.86	.85	.85	.06	-	-	-	-	-
F/G	1.15	1.07	1.11	1.06	1.1	1.05	.16	-	-	-	-	-
Day 10 to 30												
ADG, lb	1.35	1.27	1.44	1.28	1.35	1.34	.04	-	.11	-	.09	.13
ADFI, lb	2.15	2.17	2.35	2.26	2.13	2.33	.07	-	-	-	-	.10
F/G	1.60	1.71	1.63	1.76	1.58	1.74	.04	-	-	-	.01	-
Day 0 to 30												
ADG, lb	1.16	1.09	1.22	1.13	1.15	1.16	.04	-	.10	-	-	-
ADFI, lb	1.73	1.72	1.85	1.80	1.7	1.84	.06	-	-	-	-	.13
F/G	1.49	1.57	1.51	1.59	1.47	1.58	.05	-	-	-	.04	-

[a]A total of 150 pigs (five pigs/pen and five pens/treatment) with an avg initial BW of 15 lb.
[b]Replaced lactose on a wt/wt basis.
[c]Contrasts were: 1) no sugar vs other treatments; 2) lactose vs other sugars; 3) sucrose vs molasses; 4) 50 vs 100% replacement of lactose; and 5) sucrose vs molasses × 50 vs 100% replacement of lactose.
[d]Dashes indicate P>.15.

Table 6. Effects of Replacing Lactose with Sucrose in Simple and Complex Diets on Growth Performance and Apparent Nutrient Digestibility in Nursery Pigs (Exp. 3)[a]

	Simple			Complex				Contrasts[c]				
Item	No added sugar	Crystalline lactose	Sucrose[b]	No added sugar	Crystalline lactose	Sucrose[b]	SE	1	2	3	4	5
d 0 to 10												
ADG, lb	.56	.51	.60	.72	.67	.72	.04	.01	-[d]	-	.12	-
ADFI, lb	.57	.52	.58	.73	.63	.63	.04	.01	.07	-	-	-
F/G	1.02	1.02	.96	1.01	.95	.88	.08	.06	.04	-	.07	-
d 10 to 30												
ADG, lb	1.30	1.24	1.30	1.26	1.27	1.30	.04	-	-	-	-	-
ADFI, lb	1.70	1.62	1.67	1.72	1.63	1.66	.04	-	.11	-	-	-
F/G	1.31	1.30	1.29	1.37	1.28	1.28	.02	-	.02	.04	-	-
d 0 to 30												
ADG, lb	1.05	.99	1.07	1.08	1.07	1.11	.03	.06	-	-	.09	-
ADFI, lb	1.33	1.25	1.31	1.39	1.30	1.32	.05	-	.06	-	-	-
F/G	1.26	1.26	1.23	1.28	1.21	1.19	.02	.06	.01	.03	.07	-
Nutrient digestibility (d 10), %												
DM	82.0	81.3	82.2	84.6	82.5	84.2	1.0	.04	-	-	-	-
N	73.3	77.1	70.1	79.6	76.5	78.0	2.2	.05	-	-	-	.12

[a]A total of 180 pigs (six pigs/pen and five pens/treatment) with an avg initial BW of 14 lb.
[b]Replaced lactose on a wt/wt basis.
[c]Contrasts were: 1) simple vs complex; 2) no sugar vs sugars; 3) simple vs complex × no sugar vs sugars; 4) lactose vs sucrose; and 5) simple vs complex × lactose vs sucrose.
[d]Dashes indicate P>.15.