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Effects of a novel carbohydrate and protein source on sow performance during lactation[1,2]

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ABSTRACT: Ninety-one primiparous and multiparous sows and their pigs were used to evaluate the effects of a novel carbohydrate- and protein-based feed ingredient (Nutri-Pal, NP) on sow and litter performance during lactation. Nutri-Pal is a feed supplement for sows that consists of a blend of milk chocolate, brewer's yeast, whey products, and glucooligosaccharides. The dietary treatments consisted of a corn-soybean meal control and a corn-soybean meal plus 5% NP fed from d 110 of gestation to weaning. The diets were formulated to be equal in total Lys and ME. Sows were allotted to treatment based on parity, body weight, and the date of d 110 of gestation. There were 46 and 45 sows per treatment over four farrowing groups. Litters were standardized to 10 pigs and weighed within 1 d of farrowing, and all sows weaned at least 8 pigs at an average age of 21 d. Sows were weighed on d 110 of gestation, d 1 postfarrowing, and at weaning. Sows were fed three times daily during lactation. Sows were checked twice daily after weaning for signs of estrus. The weaning weight of sows fed NP was increased ($P < 0.10$) compared with those fed the control diet. Sows fed the control diet tended ($P = 0.11$) to lose more weight per day from d 110 of gestation to weaning than the sows fed NP. Otherwise, sow response variables (sow weight on d 110 of gestation and d 1 postfarrowing, d 110 of gestation to d 1 postfarrowing and lactation weight change per day, d 110 of gestation to d 1 postfarrowing, lactation, and total feed intake, days to estrus, pigs born alive or dead, and litter and average pig birth weight) were not affected ($P > 0.10$) by diet. There were no effects ($P > 0.10$) of diet on litter performance response variables (pigs weaned, litter and average pig weaning weight and gain, and survival percent). The NP feed ingredient had minor effects on sow productivity, but it did not affect litter productivity indices.

Key Words: Estrus, Feed Intake, Lactation, Litter Traits, Milk Chocolate, Sows

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Introduction

Sow litter size has increased over the last decade (USDA, 2003), which has increased the demand for milk production from the sows. Auldist et al. (1998) indicated that suckling frequency and milk yield increased linearly as litter size increased. However, this increase in the demand for milk often causes the sows to catabolize body stores during lactation, and if tissue catabolism is significant, it can affect sow performance, including days to estrus (Reese et al., 1982). Kim and Easter (2001) reported that protein mobilization in the carcass, intestinal tract, and reproductive tract of the sow increased linearly as litter size increased from 6 to 12 pigs, whereas fat mobilization remained constant. Increasing voluntary feed intake could help offset the catabolic losses incurred by the sow and permit maintenance of body condition for long-term productivity, and a more rapid return to estrus. However, voluntary feed intake by sows has not increased in parallel with the larger demand for milk production (Kim and Easter, 2001; Trottier and Johnston, 2001).

One possible way to increase feed intake may be the inclusion of highly digestible and palatable specialty ingredients in the diet. Orr and Tribble (1977) reported improved diet acceptability by lactating sows when flavoring agents were included in the diet. Pérez-Mendoza et al. (2003) reported an increase in sow feed intake and litter weaning weight when sows were fed a diet containing 12% sucrose. However, other research has indicated no improvement in sow feed intake or litter weaning weight when sows were fed diets containing 2.5% sucrose (NCR-89, 1990) or 4% sucrose plus 2% milk chocolate product (Johnston et al., 2003).

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Table 1. Composition of lactation diets (%, as-fed basis)[a]

Ingredient	C-SBM	C-SBM +5% NP
Corn	65.87	62.96
Soybean meal (47.5% CP)	28.10	26.65
Dry fat[b]	0.78	0.20
Nutri-Pal[c]	—	5.00
Monocalcium phosphate	2.01	1.98
Limestone	1.54	1.52
Trace minerals[d]	0.10	0.10
Vitamins[e]	0.50	0.50
Sodium bentonite	0.50	0.50
Salt	0.50	0.50
Choline chloride	0.10	0.10
Calculated composition		
ME, kcal/kg	3,265	3,265
Crude fat, %	4.19	3.75
Crude protein, %	18.82	18.58
Lysine, %	1.02	1.02
TSAA, %	0.63	0.62
Tryptophan, %	0.22	0.22
Threonine, %	0.71	0.71
Ca, %	1.00	1.00
P, %	0.80	0.80

[a]All diets were fed in mash form and formulated to meet or exceed the NRC (1998) requirements of lactating sows with anticipated weight change of −10 kg and pig daily weight gain of 0.20 kg. C-SBM = corn-soybean meal; NP = Nutri-Pal; TSAA = total sulfur amino acids.

[b]Fat Pak 100, Milk Specialties Co., Dundee, IL.

[c]Nutri-Pal, International Ingredient Corp., St. Louis, MO.

[d]Provided the following per kilogram of diet: Zn, 127 mg; Fe, 127 mg; Mn, 20 mg; Cu, 12.7 mg; I, 0.80 mg; Se, 0.30 mg, as zinc sulfate, ferrous sulfate, manganese sulfate, copper sulfate, calcium iodate, and sodium selenite, respectively, with calcium carbonate as the carrier.

[e]Provided the following per kilogram of diet: vitamin A, 11,023 IU; vitamin D_3, 3,307 IU; vitamin E, 88 IU; menadione (as menadione pyrimidinol bisulfite complex) 8.3 mg; riboflavin, 13 mg; Ca-D-pantothenic acid, 50 mg; niacin, 88 mg; vitamin B_{12}, 61 μg; D-biotin, 441 μg; folic acid, 3.3 mg; pyridoxine, 4.41 mg; thiamin, 4.41 mg; and vitamin C, 110 μg.

Table 2. Nutrient profile of the Nutri-Pal used in diet formulation, as-fed basis[a]

Item	
CP, %	14.0
Crude fat, %	6.0
DM, %	95.0
ME, kcal/kg	3,907
Amino acids, %	
Arginine	0.92
Histidine	0.44
Isoleucine	0.63
Leucine	1.08
Lysine	1.03
Methionine	0.24
Cystine	0.16
Phenylalanine	0.66
Tyrosine	0.38
Threonine	0.64
Trytophan	0.23
Valine	0.75
Minerals, %	
Ca	0.34
Total P	0.48
Na	0.92
K	1.34

[a]Nutri-Pal nutrient profile was provided by International Ingredients Corp., St. Louis, MO.

The objective of this experiment was to determine whether a novel carbohydrate and protein feed supplement designed to improve voluntary feed intake affected sow or litter performance.

Materials and Methods

General. Primiparous and multiparous Yorkshire and crossbred (Yorkshire × Landrace or Yorkshire × Duroc) sows from the Louisiana State University Agricultural Center Swine Unit were allotted to two dietary treatments on d 110 of gestation. The trial was conducted over four farrowing groups with a total of 91 sows. They were allotted to treatment within each group on the basis of parity, weight, and the date of d 110 of gestation. The methods used in this experiment were approved by the Louisiana State University Agricultural Center Animal Care and Use Committee.

The treatments (Table 1) consisted of a corn/soybean meal diet that served as the control or a corn/soybean meal diet with 5% Nutri-Pal (**NP**; International Ingredients Corp., St. Louis, MO), and the treatments were fed in mash form throughout the trial. Nutri-Pal is a blend of milk chocolate, brewer's yeast, whey products, and glucooligosaccharides. The diets were formulated to meet or exceed the NRC (1998) requirements of lactating sows with anticipated weight change of −10 kg and pig daily weight gain of 0.20 kg. Both diets contained 1.02% total lysine and 3,265 kcal/kg of ME (as-fed basis). The nutrient profile of NP used for diet formulation is shown in Table 2.

The sows were weighed and moved into the farrowing facility on d 110 of gestation, and at that time the treatment diets were initiated and continued until weaning. The farrowing facility is an environmentally controlled building with 28 individual farrowing stalls and an under-floor flush system. Each farrowing stall is 1.5 × 2.1 m, with a cast-iron floor for the sow and a hard plastic floor for the pigs. Each stall has a stainless steel feeder with a nipple waterer inside for the sows and a nipple waterer for the pigs. Before allotment to dietary treatment, all sows were fed a typical corn-soybean meal gestation diet that met or exceeded the nutrient requirements (NRC, 1998) of gestating sows. From d 110 to farrowing, the sows were fed approximately 3 kg/d (as-fed basis). The sows and feed containers were weighed 1 d postfarrowing for calculation of the weight change per day and ADFI from d 110 of gestation to d 1 postfarrowing.

Within 24 h of farrowing, the litters were weighed, ear-notched for identification, and given a 1-mL shot of iron dextran (Ferrodex 100; Agri Laboratories Ltd., St. Louis, MO). In addition, the umbilical cord of each pig was sprayed with iodine and needle teeth were clipped if necessary. At this time, the litters were adjusted by cross-fostering, regardless of treatment, to approximately 10 pigs and all sows weaned at least 8 pigs. The sows were not offered feed for the first day after farrowing. Beginning d 1 postfarrowing, the sows were offered feed three times a day until weaning. In the four farrowing groups, pigs were weaned at an average age of 19, 27, 20, and 20 d, respectively, and all pigs were weaned on the same day regardless of farrowing date. The sows and feed containers were again weighed at weaning for calculation of lactation weight change per day from d 1 postfarrowing to weaning and lactation ADFI. After weaning, the sows were checked twice daily for signs of estrus. Estrus was documented when the sows stood to be mounted by a boar. Sows were considered anestrous if they had not stood by d 10 postweaning; thus, no number for days to estrus was recorded for those sows. There were 11 sows—6 that were fed the control diet and 5 fed the NP diet—that did not express estrus by d 10 postweaning.

The sow response variables included weight at d 110 of gestation, d 1 postfarrowing, and at weaning; weight change per day from d 110 of gestation to d 1 postfarrowing, during lactation, and overall; ADFI from d 110 of gestation to d 1 postfarrowing, during lactation, and overall; number of days from d 110 of gestation to d 1 postfarrowing; days of lactation; days to estrus; pigs born alive, dead, and total; and total and average pig birth weight. The litter response variables included pigs nursed after cross-fostering and weaned; total and average pig weaning weight; total litter weight gain; pig ADG; and survival percent.

Statistical Analyses. Data were analyzed by analysis of variance procedures appropriate for a randomized complete block design (Steel and Torrie, 1980) using the GLM procedures of SAS (SAS Inst. Inc., Cary, NC). All data were analyzed with treatment as the main effect with farrowing group in the model. The sow was the experimental unit for all data. The following data did not have a covariate in the model: sow d 110 of gestation weight, d 110 of gestation to d 1 postfarrowing total feed intake and ADFI, d 110 of gestation to d 1 postfarrowing and lactation length, pigs born alive, dead, and total, litter and average pig birth weight, pigs nursed after cross-fostering, and pigs weaned. Sow d 110 of gestation weight was a covariate for sow d 1 postfarrowing and sow weaning weight, and sow d 110 of gestation to d 1 postfarrowing, lactation, and overall weight change per day; sow d 110 weight was significant ($P < 0.05$) as a covariate for these response variables. Lactation length was a covariate for lactation total and ADFI, overall total and ADFI, days to estrus, and survival percent; lactation length was significant ($P < 0.05$) as a covariate for lactation and overall total feed intake. Litter birth weight and lactation length were covariates for litter weaning weight and litter ADG; litter birth weight was significant ($P < 0.05$) as a covariate for both response variables but lactation length was only significant ($P < 0.05$) as a covariate for litter weaning weight. Average pig birth weight and lactation length were covariates for average pig weaning weight and pig ADG; average pig birth weight and lactation length were significant ($P < 0.05$) as covariates for average pig weaning weight. For this experiment, an alpha level of 0.10 was used to indicate significant treatment differences.

Results and Discussion

Sows fed the 5% NP diet, beginning on d 110 of gestation, were heavier at weaning than those fed the control diet ($P < 0.10$; Table 3). This heavier weight at weaning occurred even though there were no differences in weight on d 110 of gestation or d 1 postfarrowing between treatment groups. Likewise, sows fed the control diet tended ($P = 0.11$) to lose more weight per day from d 110 of gestation to weaning than those fed NP. However, there were no treatment differences in d 110 of gestation to d 1 postfarrowing or lactation weight change per day ($P > 0.10$). These results do not agree with those of Johnston et al. (2003), who reported that sows fed a diet containing 4% sucrose and 2% milk chocolate product had similar body weight at weaning compared with the control sows. However, they also reported that the sows fed the sucrose and milk chocolate product lost less weight over the lactation period than those fed the control diet. In contrast, the NCR-89 committee (1990) reported no effects on sow weight postpartum, weaning, or weight loss during lactation when feeding a diet containing 2.5% sucrose to sows.

Neither total feed intake nor ADFI were affected by diet from d 110 of gestation to d 1 postfarrowing, during lactation, or overall ($P > 0.10$). Both the NCR-89 committee (1990) and Johnston et al. (2003) also reported no differences in feed intake when sows were fed diets including highly digestible sugars. However, Pérez-Mendoza et al. (2003) reported that sows fed 12% sucrose had an increased feed intake compared with sows fed the control diet. Pérez-Mendoza et al. (2003) included sugar at a much higher level than in our study or in the studies by NCR-89 (1990) and Johnston et al. (2003). Perhaps this greater level of sugar is the reason that sows had an increased voluntary feed intake. One might expect the large increase in sugar level in the diet would increase fat stores in the sows, but Pérez-Mendoza et al. (2003) did not report sow weight data. The heavier weaning weight of the sows fed NP in our study coupled with no differences in total or ADFI suggest that the NP product may be providing more energy to the sow than was accounted for in the nutrient composition of NP when the diets were formulated. This increase in energy would allow the sow to conserve body stores of fat and protein during lactation when the demand for the sow to produce is greatest.

There were no treatment differences in d 110 of gestation to d 1 postfarrowing and lactation length ($P > 0.10$). Sows fed NP tended to have decreased days to estrus

Table 3. Effect of Nutri-Pal on sow and litter performance[a]

Treatment	C-SBM	C-SBM +5% NP	SEM	$P > F$
No. of sows	46	45		
Average parity	3.03	3.16		
Sow response variables				
Sow d 110 of gestation wt, kg	277.3	268.8	5.6	0.29
Sow d 1 postfarrowing wt, kg[b]	254.2	256.9	1.6	0.26
Sow weaning wt, kg[b]	244.0	250.3	2.6	0.10
d 110 of gestation to d 1 postfarrowing wt change, kg/d[bc]	−3.8	−3.1	0.4	0.25
Lactation wt change, kg/d[bd]	−0.53	−0.40	0.11	0.42
Overall wt change, kg/d[be]	−1.06	−0.84	0.10	0.11
d 110 of gestation to d 1 postfarrowing feed intake, kg[f]	16.6	17.6	0.9	0.44
d 110 of gestation to d 1 postfarrowing ADFI, kg/d[f]	3.50	3.33	0.11	0.29
Lactation feed intake, kg[fg]	112.3	116.4	4.4	0.52
Lactation ADFI, kg/d[fg]	5.23	5.39	0.20	0.59
Total feed intake, kg[fg]	128.7	133.8	4.4	0.43
Overall ADFI, kg/d[fg]	4.87	4.95	0.16	0.74
d 110 of gestation to d 1 postfarrowing length, d	5.00	5.42	0.27	0.28
Lactation length, d	21.34	21.30	0.33	0.94
Days to estrus, d[g]	5.06	4.67	0.20	0.18
Pigs born alive	11.11	10.57	0.40	0.34
Pigs born dead	1.78	1.42	0.26	0.33
Total pigs born	12.89	11.98	0.42	0.13
Litter birth wt, kg[h]	16.27	15.88	0.58	0.64
Average pig birth wt, kg	1.49	1.52	0.04	0.56
Litter response variables				
No. of pigs nursed after cross-fostering	10.5	10.3	0.2	0.44
Litter birth weight after cross-fostering, kg	16.40	16.50	0.44	0.89
Average pig birth weight after cross-fostering, kg	1.59	1.61	0.04	0.63
No. of pigs weaned	8.97	8.79	0.29	0.68
Litter weaning wt, kg[i]	52.4	53.4	2.1	0.75
Average pig weaning wt, kg[j]	5.89	6.08	0.13	0.30
Litter ADG, kg[ik]	1.67	1.71	0.09	0.74
Pig ADG, kg[kl]	0.20	0.21	0.01	0.28
Survival, %[gm]	85.17	85.84	2.31	0.84

[a]Experimental diets were initiated on d 110 of gestation and continued through weaning. C-SBM = corn-soybean meal; NP = Nutri-Pal.

[b]Treatment means reported were adjusted using sow weight at d 110 of gestation as a covariate.

[c]Weight change from d 110 of gestation to d 1 postfarrowing was calculated as the difference in sow weight at d 1 postfarrowing and sow weight at d 110 of gestation.

[d]Lactation weight change was calculated as the difference in sow weaning weight and sow weight at d 1 postfarrowing.

[e]Sow weight change was calculated as the difference in sow weaning weight and sow weight at d 110 of gestation.

[f]Total and ADFI are expressed on an as-fed basis.

[g]Treatment means reported were adjusted using lactation length as a covariate.

[h]Litter birth weight was calculated as litter birth weight of live pigs divided by number of live pigs at farrowing.

[i]Treatment means reported were adjusted using litter birth weight and lactation length as covariates.

[j]Treatment means reported were adjusted using average pig birth weight and lactation length as covariates.

[k]Litter ADG was calculated as (litter weaning weight minus litter birth weight after cross-fostering) divided by lactation length.

[l]Pig ADG was calculated as (average pig weaning weight minus average pig birth weight after cross-fostering) divided by lactation length.

[m]Percentage of survival was calculated as number of pigs weaned divided by number of pigs nursed after cross-fostering.

(4.67 vs. 5.06), but the effect was not significant (P = 0.18). This numerical decrease in weaning-to-estrus interval in our trial agrees with data from the NCR-89 committee (1990), who also reported a smaller weaning-to-estrus interval in sows fed 2.5% sucrose compared with those fed the control diet. Johnston et al. (2003)

reported a numerical increase in the percentage of sows displaying estrus for those fed the 4% sucrose and 2% milk chocolate product. However, they also reported a numerical increase in weaning-to-estrus interval in sows fed the 4% sucrose and 2% milk chocolate product compared with the control diet.

Diet did not affect pigs born alive or dead or litter and average pig birth weight ($P > 0.10$). The NP was only fed for an average of 5 d before farrowing. Neither the NCR-89 committee (1990) nor Johnston et al. (2003) reported any treatment differences in total pigs born, pigs born alive, or total weight at birth. After cross-fostering, there was no difference in number of pigs nursed or weaned ($P > 0.10$). Diet did not affect pig or litter ADG or survival percent ($P > 0.10$). The NCR-89 (1990) and Johnston et al. (2003) reported similar results. However, Pérez-Mendoza et al. (2003) reported heavier litter weights at weaning for those pigs nursing sows fed 12% sucrose compared with those fed the control diet.

The purpose of this research was to determine whether a novel carbohydrate and protein source would affect feed intake of sows, which may result in greater pig growth from birth to weaning. Sow weaning weight was increased by Nutri-Pal addition to the diet, and this was the only response variable significantly affected by diet. However, lactation and overall weight loss and days to estrus were numerically decreased and lactation ADFI was numerically increased by Nutri-Pal addition to the diet. Accompanied with the positive results of Pérez-Mendoza et al. (2003) when sow's diets were supplemented with 12% sucrose, the data combined suggest that sucrose and/or other disaccharide additions to diets for sows may increase feed intake and overall sow prolificacy. Our results and those of the NCR-89 committee (1990) and Johnston et al. (2003) suggest that the addition of sugar may have to be greater than 5% of the diet.

The results of this trial indicate potential benefits of feeding excess carbohydrates to lactating sows. There is considerable amount of research still to be conducted, however, to determine the form of sugar and the level of inclusion in the diet that maximizes voluntary feed intake and minimizes sow weight loss.

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