THE EFFECT OF CARBOHYDRATE SOURCE AND EXTRUSION PROCESSING ON GROWTH PERFORMANCE ON SEGREGATED EARLY-WEANED PIGS[1]

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Summary

A 21-day growth trial was conducted to determine the effect of various carbohydrate sources with or without moist extrusion processing on growth performance of segregated early-weaned pigs. Treatments included five different carbohydrate sources (corn, corn starch, rice, wheat flour, and grain sorghum) with or without moist extrusion processing in a 2 × 5 factorial arrangement. No interactions were observed among carbohydrate sources and extrusion processing. Growth performance was not improved by extrusion processing. Surprisingly, pigs fed corn had poorer growth performance compared to those fed other carbohydrate sources. These results suggest that corn starch, rice, wheat flour, and grain sorghum are suitable alternatives to corn in diets for segregated early-weaned pigs.

(Key Words: Segregated Early-Weaned Pigs, Extrusion, Carbohydrate Sources.)

Introduction

In the United States, corn is the predominate energy source used in swine diets. However, in Asia and other parts of the world, many other carbohydrate sources are available and less expensive than corn. Therefore, the objective of this study was to evaluate the effects of various carbohydrate sources on growth performance of the segregated early-weaned pig. In addition, a second objective was to determine the possible beneficial effects of moist extrusion processing of the carbohydrate sources and effects of any potential interactions between the different carbohydrate sources and moist extrusion processing on pig growth performance.

Procedures

Three hundred and fifty high-lean growth potential and high health pigs were weaned initially at 10 ± 2 d of age and delivered to the segregated early-weaning (SEW) facilities at Kansas State University. The pigs were blocked by weight (initially 9.7 ± 2.0 lb) and allotted to one of 10 experimental diets. Each treatment had five pigs per pen and seven replications (pens). Treatments were arranged in a 2 × 5 factorial with main effects including carbohydrate sources (corn, corn starch, wheat flour, rice, and grain sorghum) with or without moist extrusion processing.

In this study, only carbohydrate sources were extruded through a Wenger X-20 single screw extruder, mixed in the respective diets, then pelleted in a pellet mill equipped with a 3/32 in. die. The extruder conditions were 280°F barrel jacket temperature at 8th head, 300 psig cone pressure, 5 lb/min retention time, and approximately 212°F temperature of materials exiting the extruder.

The trial was divided into two phases (Table 1). Pigs were weaned and fed a complex diet from d 0 to 7 postweaning. All diets contained 42% of the respective carbo-

[1]The authors thank Newsham Hybrids, Colorado Springs, CO, for providing the pigs used in this experiment.

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hydrate sources, 20% dried whey, 10% moist extruded soy protein concentrate, 6.7% spray-dried plasma protein, and 6% select menhaden fish meal. Diets were formulated to 1.7% total lysine, with all other amino acids above suggested estimates based on current ratios relative to lysine. The amounts of synthetic lysine and methionine varied slightly among experiment diets based on differences in lysine concentration of the carbohydrate sources. During d 7 to 21 postweaning, pigs were fed transition diets containing 47% of their respective carbohydrate source, 15.5% soybean meal, 10% dried whey, 5% select menhaden fish meal, and 3% spray-dried plasma protein. Diets were formulated to 1.5% total lysine.

In our diet formulation, the various carbohydrate sources were maximized by reducing the amount of dried whey and supplemental lactose as well as decreasing the amounts of fat added to the diets compared to levels typically observed in some commercial diet formulations. Therefore, the addition of carbohydrate sources was maximized to better evaluate them in this study.

During the experiment, pigs were housed at the Kansas State University SEW facilities in environmentally controlled 4 × 4 ft pens and allowed ad libitum access to water and feed. Temperature was maintained at 95°F for the first week and then gradually reduced for pig comfort. The pigs were weighed and feed disappearance was determined on d 7,14, and 21 postweaning. Average daily gain, ADFI, and F/G were the response criteria. Data were analyzed as a randomized block design in a 2 × 5 factorial arrangement for carbohydrate × extrusion processing. Analysis of variance was performed using the GLM procedure of SAS.

Results and Discussion

In this study, no carbohydrate sources by extrusion processing interactions ($P>.10$) were observed (Table 2). From d 0 to 7 postweaning, ADG surprisingly was poorer for pigs fed diets containing corn compared to pigs fed any of the other carbohydrate sources ($P<.01$). Pigs fed rice or grain sorghum had the greatest ADG, whereas pigs fed corn starch and wheat flour had intermediate ADG. Pigs fed the extruded diets had an ADG of .51 lb/d, which was not different than that of pigs fed the nonextruded diets (.54 lb/d, $P>.10$). Average daily feed intake followed a similar trend, in that pigs fed corn had the lowest ADFI. However, pigs fed corn only tended to be different from those pigs fed either rice or grain sorghum ($P<.10$). Pigs fed corn starch and wheat flour had intermediate ADFI. Extrusion processing had no effect on ADFI ($P>.10$); pigs fed the extruded carbohydrate sources diet had an ADFI of .46 lb/d and those fed the nonextruded diet had an ADFI of .44 lb/d. Feed efficiencies were excellent across all dietary treatments. The excellent F/G observed during the first week of the study was a result of the pigs rehydrating after delivery from Colorado. The different carbohydrate sources had no effect on F/G for the first 7 d of the study ($P>.10$). However, numerical trends were the same as for ADG and ADFI; pigs fed diets containing corn had numerically poorer F/G than those fed corn starch, rice, wheat flour, or grain sorghum. In addition, extrusion processing of carbohydrate sources had significant effects on F/G ($P<.05$), and pigs fed the extruded diets had poorer F/G than those fed the nonextruded diets. This was the only significant extrusion effect that was observed throughout the study.

From d 7 to 21, pigs were fed their respective transition diet. Average daily gain during this transition period followed the same trends with pigs fed the corn-based diet having significantly poorer ADG ($P<.10$) compared to pigs fed corn starch, wheat flour, or grain sorghum. Those pigs fed rice had intermediate ADG. No significant differences in ADG ($P>.10$) occurred for pigs fed extruded versus nonextruded carbohydrate sources. Average daily feed intake was not influenced by either carbohydrate source or moist extrusion processing of carbohydrate sources ($P>.10$). However, pigs fed the corn-based diet had poorer F/G compared to those fed either corn starch, wheat flour, or grain sorghum ($P<.10$). Pigs fed the rice-based diet had poorer F/G compared to those fed either corn starch, wheat flour, or grain sorghum ($P<.10$). Moist extrusion processing of carbohydrate sources had no significant effects on F/G ($P>.10$).

For the overall study (d 0 to 21 postweaning), pigs fed the corn-based diet surprisingly had poorer ADG than those fed either corn starch, rice, wheat flour, or grain sorghum ($P<.01$). In addition, extrusion processing of carbohydrate sources had no effect on ADG. However, ADFI was not influenced by either carbohydrate sources or moist extrusion processing. Finally, for the overall study, pigs fed the corn-based diet had poorer F/G than those fed either corn starch, rice, wheat flour, or grain sorghum ($P<.01$). Again, no overall differences were observed in terms of F/G ($P>.10$) for pigs fed either extruded carbohydrate sources or nonextruded carbohydrate sources.

Based on these results, pigs fed the corn-based diet had decreased ADG and F/G compared to pigs fed other carbohydrate sources. We have no explanation for that negative response. Analyses of corn quality (test weight, nutrients, etc.) were within normal allowances. In addition, the corn was checked and found to be free of mycotoxins. Therefore, results of this study suggest that ingredients such as corn starch, wheat flour, rice, and grain sorghum are viable alternatives for use as carbohydrate sources in diets for segregated early-weaned pigs.

Table 1. Compositions of Experimental Diets

Ingredient, %	SEW[a]	Transition[b]
Carbohydrate source[c]	42.00	47.00
Dried whey	20.00	10.00
Moist extruded soy protein concentrate	10.38	6.00
Plasma protein	6.70	3.00
Fish meal	6.00	5.00
Soybean meal	5.00	15.49
Soybean oil	4.00	4.00
Egg protein	2.00	2.50
Wheat gluten	---	2.50
Vitamins and minerals	3.83	4.49
Lysine and methionine[d]	---	---
Antibiotic[e]	1.00	1.00
Total	100.00	100.00

[a]Diets were formulated to contain 1.7% lysine, .48% methionine.
[b]Diets were formulated to contain 1.5% lysine, .42% methionine.
[c]Carbohydrate sources included corn, corn starch, wheat flour, rice, and grain sorghum with or without moist extrusion processing.
[d]The amounts of synthetic lysine and methionine varied slightly among experimental diets based on differences in lysine concentration of the carbohydrate source.
[e]Provided 50 g/ton carbadox.

Table 2. **The Effects of Extruding Carbohydrate Sources on Growth Performance of Early-Weaned Pigs**[a]

	Extruded					Nonextruded					
Item,	Corn	Corn Starch	Rice	Wheat Flour	Grain Sorghum	Corn	Corn Starch	Rice	Wheat Flour	Grain Sorghum	CV
d 0 to 7											
ADG, lb[b]	.45	.46	.54	.49	.61	.45	.58	.58	.54	.56	17.06
ADFI, lb[c]	.46	.43	.49	.44	.51	.39	.46	.48	.45	.43	13.48
F/G[d]	1.02	.93	.91	.90	.84	.87	.79	.83	.83	.77	16.60
d 7 to 21											
ADG, lb[c]	1.04	1.11	1.11	1.10	1.09	.96	1.11	1.06	1.22	1.12	12.69
ADFI, lb	1.33	1.34	1.36	1.31	1.34	1.29	1.37	1.38	1.35	1.35	7.03
F/G[c]	1.28	1.21	1.23	1.19	1.23	1.34	1.23	1.30	1.11	1.21	10.58
d 0 to 21											
ADG, lb[b]	.75	.77	.81	.78	.83	.71	.85	.79	.83	.80	8.48
ADFI, lb	.90	.88	.93	.88	.93	.85	.93	.94	.92	.89	6.97
F/G[b]	1.20	1.14	1.15	1.13	1.12	1.20	1.09	1.19	1.11	1.11	6.63

[a]Three hundred and fifty weanling pigs (initially 9.7 ± 2 lb and 10 ± 2 d of age were used with five pigs/pen and seven pens/treatment.
[b,c]Carbohydrate effect ($P<.01$ and .10, respectively).
[d]Extrusion effect ($P<.05$).