Effect of Dietary Energy Source and Free Choice Feeding on Performance of High Lean Pigs

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Summary and Implications

The effects of dietary energy sources in corn on the growth responses and carcass composition of high lean pigs fed from 55 to 110 kg body weight were evaluated. Low fiber composite corns were created by replacing the fiber in normal corn with isocaloric amounts of either corn starch or corn oil. Feeding the low fiber, composite corns reduced the amount of feed required per unit of body weight compared with that of pigs fed the high fiber, normal corns. However, the daily body weight and muscle gains and efficiency of metabolizable energy (ME) utilization for body weight and muscle gain were similar among pigs fed the low and high fiber corns. Body composition (backfat, loin muscle area, and muscle mass) at 110 kg body weight also were similar among corn treatments. When given the choice between the normal and composite corns, pigs consumed more of the low fiber composite corn with added fat but not with added starch. The feed required per unit of gain also was reduced in pigs allowed free choice access to normal and composite corns compared with pigs self-fed the normal corns. Pig growth and body composition were not altered by free choice selection of normal and composite corns.

Introduction

High lean pigs are more dependent on energy intake to achieve maximum muscle growth than are fat pigs. Thus, the value of a highly palatable, highly digestible energy source may be greater as the pigs' capacity for muscle growth is increased.

Corn is a common energy source used in swine diets even though it contains 8 to 12% neutral detergent fiber (NDF), which is less effectively digested by pigs than other corn components. Furthermore, the digestive end products of fiber are used less efficiently for muscle growth than those of the starch and fat components of corn. Consequently, removing the fiber in corn and replacing it with an equal amount of gross energy from either starch or oil may enhance the performance of high lean pigs and reduce the amount of undigested excreta in animal waste.

Metabolically, starch calories may enhance muscle growth in high lean pigs. Furthermore, starch calories seem to be preferentially used by white muscle fibers, the predominant fiber type in high lean pigs. In contrast, fat calories seem to be used preferentially for body fat accretion and by red muscle fibers, the predominant fiber type in fatter genetic strains.

Pigs normally consume sufficient amounts of feed to meet their metabolic energy needs for growth. The use of a feeding system that allows pigs to choose the optimum amount of diets containing differing amounts of corn fiber versus corn starch or oil may allow greater levels of productivity to be achieved by high lean pigs. Also, by giving pigs the choice, the dietary preference and biological value of corns in which the corn fiber is replaced with either starch or oil could be estimated.

The objective of this study was to determine the effect of dietary energy source (replacing corn fiber with corn starch or oil) and the method of energy source presentation (fixed or free choice) on growth responses of high lean pigs.

Materials and Methods

Eighteen sets of three littermate barrows were used in this study. At 55±4.6 kg of body weight, pigs were randomly allotted to one of six dietary energy sources. The pigs in each litter were self-fed either a normal corn diet, a composite corn diet that had the corn fiber replaced with corn starch or oil, or given free choice access to the normal corn and the respective composite corn.

To create the different dietary energy sources, 80% of the fiber in the normal corn was replaced with isocaloric amounts of gross energy from either corn starch or corn oil to create composite corns with a low fiber content but higher amounts of either starch or fat. Each diet was formulated to contain the same amount of nutrients as well as the same proportion of each nutrient source per unit of corn gross energy. The composition of the diets is shown in Table 1.

Pigs were penned individually and given ad libitum access to feed and water. The pigs given the choice of diets had access to a feeder containing the normal corn diet and a feeder containing the composite corn diet. During an initial 4-day adaptation period, pigs were given access only to one of the two diets and the diet was changed daily. Subsequently, both diets were provided simultaneously and the position of the feeders was rotated every other day so the pig would not become acclimated to the location of a particular feeder. Initial ambient temperature of the building was 76°F and was dropped .5°F every 7 days until a room temperature of 70°F was reached.

Pig weights and feed consumption were measured at 7-day intervals until the pigs individually reached 110±3.9 kg. Real-time ultrasound measurements were taken at 55±4.6 kg, 82.5±2.7 kg, and 110±3.9 kg to determine backfat and loin muscle area. Initial lean tissue was calculated by multiplying live weight by 41%. Final lean tissue weight (kg) was calculated using the following equation for a 110 kg pig:

= 9.38 + (.32*live weight, kg) + (-2.84*backfat, cm) + (.18*loin muscle area, cm^2) (1).

Pigs were bled via the jugular vein at the initiation and termination of the study to determine the presence of serum antibody titers for actinobacillus pleuropneumoniae, mycoplasma hyopneumonia, porcine reproductive and respiratory syndrome, swine influenza virus, and transmissible gastroenteritis virus and to determine serum concentrations of the acute-phase protein alpha-1 acid glycoprotein (AGP).

Data were analyzed by variance techniques using the GLM procedure of SAS. The pig was considered the experimental unit. Treatment effects were analyzed as nonorthogonal contrasts. Comparisons were made to determine the responses of pigs to: (1) normal corn versus the composite corns, (2) normal corn versus free choice of normal corn and composite corns, (3) normal corn versus the composite corn with starch as the energy source, (4) normal corn versus the choice between normal corn and the composite corn with starch, (5) normal corn versus the composite corn with fat as the energy source, and (6) normal corn versus the choice between normal corn and the composite corn with fat. Responses over time were analyzed as a repeated measure.

Results and Discussion

Immune status of pigs. The experimental pigs were from a high lean strain of animals. From previous research, the pigs produced carcasses with 54 to 56% muscle. As shown in Table 2, the pigs in this study were free of antibody titers for the five antigens evaluated. Serum AGP concentrations averaged 555 µg/ml at the initiation and 473 µg/ml at the termination of the study. From previous research done at our station, these AGP concentrations would indicate that the pigs experienced a low level of antigen exposure (2) and thus would have a high capacity for muscle growth.

Effects of low fiber, composite corns (55 to 110 kg body weight). Replacing the fiber in corn with isocaloric amounts of more digestible corn starch or corn oil resulted in a greater ME content of the respective composite corns and diets. Feeding the low fiber composite corns resulted in less feed being required per unit of body weight gain (Table 3). However, daily rate of body and muscle gains and the amount of ME required per unit of gain did not differ among corns. Body composition, measured as backfat thickness longissimus muscle area, and body muscle mass also was not altered by corn composition.

Pigs given free choice access to the normal corn and the composite corns required less feed per unit of gain compared with pigs self-fed the normal corn. However, the amount of GE (gross energy) and ME required per unit of gain, daily body weight and muscle gains, and body composition were not altered by free choice selection of the normal and composite corns.

Responses of the pigs to the individual composite corns. Feeding the low fiber composite corns with added starch or oil resulted in less feed being required per unit of body weight gain compared with normal corn (Table 4). Body weight gains were less for pigs consuming the composite corn with added starch but were not altered for pigs consuming the composite corn with added fat compared with pigs fed the normal corn diet. GE utilization was improved for pigs consuming the composite corn with added fat, but was not altered for those consuming the composite corn with added starch. Despite the improved efficiency of GE utilization in pigs consuming fat, ME was not used more efficiently for gain. Feeding either of the low fiber composite corns did not alter body composition at 110 kg of body weight (Table 5).

When given the choice between the normal and composite corns, pigs consumed more of the composite corn with added fat but not with added starch over the

Table 2. Immune status of the pigs.

	Pig weight, kg	
Criteria	55	110
Serum antibody titers[a]		
APP	-	-
MP	-	-
PRRS	-	-
SIV	-	-
TGE	-	-
AGP, µg/ml	555	473

[a]Actinobacillus pleuropneumoniae (APP), mycoplasma hyopneumonia (MP), porcine reproductive and respiratory syndrome (PRRS), swine influenza virus (SIV), and transmissible gastroenteritis virus (TGE).

Table 1. Composition of diets.

Ingredient	Dietary Energy Source		
		Composite Corn (CC)	
	Normal Corn (NC)	With Starch	With Fat
Corn	67.51	0.00	0.00
Corn starch	2.04	57.93	52.26
Corn bran	2.49	0.00	0.00
Corn gluten meal	0.00	8.89	9.38
Corn oil	0.00	2.82	6.36
Soybean meal, dehulled	24.20	25.73	27.11
L-lysine·HCl	.13	.14	.14
Tryptosine	.07	.21	.22
L-threonine	.03	.10	.11
DL-methionine	.02	.07	.08
Dical phosphate	1.81	2.09	2.2
Limestone	.66	.66	.70
Salt	.40	.42	.44
Mineral mix[a]	.10	.10	.11
Selenium mix	.05	.05	.06
Vitamin mix[b]	.25	.26	.28
Choline Cl, 60%	.20	.21	.22
Santoquin	.02	.02	.02
Mg sulfate	0.00	.17	.18
Potassium Cl	0.00	.09	.10
Antibiotic	.02	.03	.03
Calculated Composition			
GE, Mcal/kg	3.77	4.08	4.27
ME, Mcal/kg	3.28	3.76	3.89
Analyzed Composition			
Dry matter, %	87.43	91.06	90.85
Crude protein, %	17.07	18.52	19.27
Fat, %	3.04	3.18	6.61
NDF, %	10.67	2.90	3.54

[a]Contributes the following per kilogram of diet: zinc, 150 ppm; iron, 175 ppm; manganese, 60 ppm; copper, 17.5 ppm; iodine, 2 ppm.

[b]Contributes the following per kilogram of diet: Biotin, .1 mg; folic acid, .8 mg; niacin, 49.1 mg; pantothenic acid, 31.6 mg; riboflavin, 10.6 mg; pyridoxine, 8 mg; thiamine, 4.6 mg; vitamin E, 38.1; vitamin A, 5709 IU; vitamin D, 1102 IU; vitamin K, 2 mg; vitamin B_{12}, .032 mg; vitamin C, 100 mg.

duration of the study (Table 6). It was expected that pigs would consume more of the starch diet at the lighter body weights when muscle growth predominates and more of the fat diet at heavier body weights when more body fat is deposited. The amount of feed required per unit of gain was reduced in pigs given free choice access to the normal and composite corn with added fat but not with added starch compared with pigs self-fed the normal corn. Body weight gain, efficiency of ME utilization, and body composition were not altered by the free choice selection of the normal and composite corns.

Table 6. Percentage of total feed intake of normal corn vs. composite corn diets for pigs given free choice access to the two diets from 55 to 110 kg.

Criteria	Substituted Energy Source	Normal Corn (NC)	Composite Corn (CC)
% Intake	Starch	54.1	45.9
	Fat	34.7	65.3

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References

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Table 3. Main effects of normal vs. composite corns on performance of high lean pigs fed from body weights of 55 to 110 kg.

Criteria	Dietary Energy Source			Probability[a]	
	Normal Corn (NC)	Composite Corn (CC)	Free choice (FC)	NC vs. CC	NC vs. FC
Pig weight, kg					
Initial	54.5	55.7	54.4		
Final	109.2	109.7	109.9		
Feed and energy intake					
Feed, kg/day	2.68	2.17	2.58	.01	NS
GE, Mcal/day	10.13	9.04	10.28	.01	NS
ME, Mcal/day	8.80	8.28	9.20	NS	NS
Body weight and muscle gains					
Weight gain, kg/day	.85	.81	.88	NS	NS
Muscle gain, kg/day	.340	.331	.363	NS	NS
Efficiency of feed and energy utilization					
Feed:Weight Gain, kg/kg	3.20	2.71	2.94	.01	.01
GE:Weight Gain, Mcal/kg	12.09	11.30	11.73	.01	NS
ME:Weight Gain, Mcal/kg	10.51	10.35	10.50	NS	NS
Body composition (at 110 kg body weight)[c]					
Backfat, cm	2.47	2.35	2.34	NS	NS
L. muscle area, cm^2	39.71	40.60	40.97	NS	NS
Muscle weight, kg	44.47	45.10	45.29	NS	NS
Muscle, % of body gain	40.47	41.35	41.34	NS	NS

[a] NS = nonsignificant differences.
[b] GE = gross energy; ME = metabolizable energy.
[c] Body composition estimated from real-time ultrasound measurements.

Table 4. Effect of dietary energy source (starch vs. fat) in composite corn on performance of high lean pigs fed from 55 to 110 kg body weight.

Criteria	Composite corn energy source	Dietary Energy Source: Normal Corn (NC)	Composite Corn (CC)	Free choice (FC)	Probability[a]: NC vs. CC	NC vs. FC
Feed and energy intakes						
Feed, kg/day	Starch	2.78	2.16	2.73	.01	NS
	Fat	2.58	2.17	2.42	.01	NS
GE, Mcal[b]/day	Starch	10.50	8.81	10.67	.01	NS
	Fat	9.75	9.27	9.88	NS	NS
ME, Mcal[b]/day	Starch	9.13	8.11	9.54	.02	NS
	Fat	8.48	8.44	8.86	NS	NS
Body weight and muscle gains						
Weight gain, kg/day	Starch	.88	.76	.91	.01	NS
	Fat	.81	.85	.85	NS	NS
Muscle gain, kg/day	Starch	.347	.315	.366	NS	NS
	Fat	.333	.346	.359	NS	NS
Efficiency of feed and energy utilization						
Feed:Weight Gain, kg/kg	Starch	3.19	2.85	3.02	.01	NS
	Fat	3.21	2.57	2.85	.01	.01
GE:Weight Gain[b], Mcal/kg	Starch	12.06	11.62	11.80	NS	NS
	Fat	12.12	10.97	11.65	.01	NS
ME:Weight Gain[b], Mcal/kg	Starch	10.48	10.71	10.55	NS	NS
	Fat	10.53	9.99	10.45	NS	NS
GE:Muscle Gain, Mcal/kg	Starch	29.69	33.18	27.01	NS	NS
	Fat	29.23	27.92	26.60	NS	NS
ME:Muscle Gain, Mcal/kg	Starch	26.48	29.61	24.25	NS	NS
	Fat	26.05	24.82	23.75	NS	NS

[a] NS = nonsignificant differences.
[b] GE = gross energy; ME = metabolizable energy.

Table 5. Effect of dietary energy source (starch vs. fat) in composite corn on body composition of high lean pigs at market weight (110 kg body weight).

		Dietary Energy Source			Probability[a]	
Criteria	Composite Corn Energy Source	Normal Corn (NC)	Composite Corn (CC)	Free Choice (FC)	NC vs. CC	NC vs. FC
Backfat, cm	Starch	2.59	2.32	2.50	NS	NS
	Fat	2.35	2.38	2.17	NS	NS
L. muscle area, cm^2	Starch	38.86	40.66	40.52	NS	NS
	Fat	40.56	40.54	41.41	NS	NS
Muscle wt, kg	Starch	44.13	44.88	44.78	NS	NS
	Fat	44.80	45.31	45.80	NS	NS
Muscle, % of gain	Starch	39.53	41.61	40.31	NS	NS
	Fat	41.41	41.08	42.36	NS	NS

[a] NS = nonsignificant differences.