Bioenergy Co-products as Swine Feed Ingredients: Combining DDGS and Glycerol

A.S. Leaflet R2460

Mark S. Honeyman, professor; Peter J. Lammers, research associate, Department of Animal Science;
Brian J. Kerr, associate professor, USDA-ARS Swine Odor and Manure Management Research Unit

Summary and Implications

Bioenergy production generates two major co-products—distillers dried grains with solubles (DDGS) from ethanol plants and crude glycerol from biodiesel plants. We need to evaluate whether these co-products, DDGS and glycerol, can be fed in combination to partially meet the feed energy needs of growing pigs. If successful, the diet with 25% DDGS and 10% glycerol has the potential to reduce corn feeding to market pigs by 40+%. The objective was to evaluate feeding crude glycerol and DDGS in combination to market swine. At the processing plant, a fat sample was taken from the jowl of each pig. The fat sample was analyzed for fatty acids. Pig performance and carcass traits did not differ between diets. Fatty acid composition showed differences based on the dietary treatments. Saturated fatty acids were highest for diets with the most corn and least DDGS – the corn-soy and 10% glycerol diets ($P < 0.01$). Mono unsaturated fatty acids were highest for the 10% glycerol diet and decreased as DDGS was added with the lowest value for the 25% DDGS diet ($P < 0.01$). Poly-unsaturated fats were lowest for the corn-soy and 10% glycerol diets and highest for the 25% DDGS diets ($P < 0.001$). The results of this study show that pig performance was not affected by the addition of DDGS and crude glycerol. The amount of corn fed can be reduced by the addition of DDGS and glycerol. DDGS increases the unsaturated fatty acids in pork fat. Crude glycerol addition partially offsets the DDGS fatty acid effect by reducing polyunsaturated fatty acid content.

Introduction

Bioenergy production generates two major co-products – distillers dried grains with solubles (DDGS) from ethanol plants and crude glycerol from biodiesel plants. Energy-rich feedstuffs for pigs, especially corn, are increasingly expensive. As the bioenergy expansion continues, we need to evaluate whether these co-products, DDGS and glycerol, can be fed in combination to partially meet the feed energy needs of growing pigs. If successful, the diet with 25% DDGS and 10% glycerol has the potential to reduce corn feeding to market pigs by 40+%. The objective was to evaluate feeding crude glycerol and DDGS in combination to market swine. There were six dietary treatments fed in three phases: 1) 0% glycerol, 0% DDGS or a corn-soy diet control; 2) 0% glycerol, 15% DDGS; 3) 0% glycerol, 25% DDGS; 4) 10% glycerol, 0% DDGS; 5) 10% glycerol, 15% DDGS; and 6) 10% glycerol, 25% DDGS. The diets were formulated to be equal in energy and amino acids for the pigs, and thus pig performance was expected to be equal.

Materials and Methods

There were six dietary treatments fed in three phases: 1) 0% glycerol, 0% DDGS or a corn-soy diet control; 2) 0% glycerol, 15% DDGS; 3) 0% glycerol, 25% DDGS; 4) 10% glycerol, 0% DDGS; 5) 10% glycerol, 15% DDGS; and 6) 10% glycerol, 25% DDGS. The diets were formulated to be equal in energy and amino acids for the pigs, and thus pig performance was expected to be equal (Table 1).

The experimental design was a 2 × 3 factorial arrangement with 2 levels of glycerol (0 to 10%) and 3 levels of DDGS (0, 15, and 25%). Pigs were fed from 87 lb to 275 lb (market). There were three dietary phases. Pigs were housed in pens of four head with six replications per treatment. Thus, 6 treatments × 6 reps = 36 pens × 4 pigs = 144 pigs. All pigs were scanned prior to market for backfat and loin area. Experimental unit was a pen of 4 pigs. At the processing plant, a fat sample was taken from the jowl of each pig. The fat sample was analyzed for fatty acids. Analysis of variance for the 6 dietary treatments and interactions were examined.

The glycerol had an ME of 1432 kcal/lb as fed with adjustments for fat content and dry matter. The salt content was 5.37%. The DDGS laboratory analysis was 1.14 lysine, 1.12 threonine, and 0.22 tryptophan. The calculated DDGS SID was 68.5 lysine, 74.7% threonine and 70.8 tryptophan. The DDGS was analyzed at 29.15% CP, 11.08% EE, 5.69% crude fiber, and 3.99% ash. The calculated corn SID was 85.5% lysine, 54.8% threonine, and 87.0% tryptophan. The calculated soybean meal SID was 91.9% lysine, 87.4% threonine, and 91.2% tryptophan. When DDGS was added to the corn-soy diets, the approximate substitution was: Add 100 kg DDGS, 1.7 kg limestone, and 0.15 kg lysine, and remove 76 kg corn, 23 kg SBM, and 3 kg dicalcium phosphate. When glycerol was added to the corn-soy diet, the approximate substitution was: Add 100 kg glycerol and 8 kg SBM, and remove 104 kg corn and 4 kg salt.

Results and Discussion

Pig performance and carcass traits did not differ between diets (Table 2). Fatty acid composition as percentages of ten fatty acids analyzed from the pork fat sample as shown in Table 3. Fatty acid composition showed differences based on the dietary treatments. Fatty acid C16:0 was higher in the corn-soy and 10% glycerol diets ($P < 0.001$). Fatty acid C16:1 was lowest for the diets with

DDGS only (15 and 25%) and highest for the corn-soy and 10% glycerol diets—the two diets with no DDGS ($P < 0.01$). The fatty C17:1 was higher for the corn-soy and 10% glycerol diets than the two diets with 25% DDGS ($P < 0.01$). Fatty acid C18:0 was higher for corn-soy diets than the 25% DDGS diet, the 15% DDGS plus 10% glycerol diet, and the 25% DDGS plus 10% glycerol diet ($P < 0.01$). Fatty acid C18:1 was highest for the 10% DDGS diet ($P < 0.01$). Fatty acid C18:2 was highest for the 25% DDGS diet and lowest for the corn-soy and 10% glycerol diets ($P < 0.001$). For fatty acid C18:3 was lowest for the 10% glycerol diet ($P < 0.01$). Saturated fatty acids were highest for diets with the most corn and least DDGS – the corn-soy and 10% glycerol diets ($P < 0.01$). Mono unsaturated fatty acids were highest for the 10% glycerol diet and decreased as DDGS was added with the lowest value for the 25% DDGS diet ($P < 0.01$). Poly-unsaturated fats were lowest for the corn-soy and 10% glycerol diets and highest for the 25% DDGS diets ($P < 0.001$).

The fatty acid profile followed expected trends when DDGS was added. DDGS is higher in corn oil than corn and causes softer, oiler, less saturated fats, and more unsaturated fats. Interestingly, the addition of crude glycerol with almost no fatty acids and the removal of corn with about 3% oil, results in diets lower in corn oil. Thus, the added glycerol partially offset the DDGS effect of soft, oily pork fat.

The results of this study show that pig performance was not affected by the addition of DDGS and crude glycerol. The amount of corn fed can be reduced by the addition of DDGS and glycerol. DDGS increases the unsaturated fatty acids in pork fat. Crude glycerol addition partially offset the DDGS fatty acid effect by reducing polyunsaturated fatty acid content.

Acknowledgements

The authors gratefully acknowledge the support of the Agricultural Marketing Resource Center at ISU, the Iowa Grain Quality Initiative, Hawkeye Gold, LLC, Ames, IA, Central Iowa Energy, Newton, IA, DSM Nutritional Products, Ames, IA, Dr. Dong Ahn for fatty acid analysis, the ISU Swine Nutrition Farm, and Arlie Penner for pig care, feed mixing, and data analysis.

Table 1. Composition and calculated analysis of diets by phase.

Treatment	Corn-soy			15% DDGS/0% Glyc			25% DDGS/0% Glyc		
Phase	1	2	3	1	2	3	1	2	3
Corn	733.0	785.0	835.0	620.0	672.0	722.0	544.0	598.0	645.0
SBM	238.0	190.0	142.0	203.0	155.0	107.0	180.0	132.0	85.0
DDGS	0.0	0.0	0.0	150.0	150.0	150.0	250.0	250.0	250.0
Glycerol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lysine	1.1	0.7	0.6	1.3	0.9	0.8	1.5	1.1	1.0
Dical Phos	12.0	9.2	7.3	7.5	4.7	2.8	4.5	0.0	0.0
Limestone	7.9	7.1	7.1	10.2	9.4	9.4	12.0	10.9	11.0
Salt	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Vit mix	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
TM Mix	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Se Mix	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
Calculated analysis, (% unless noted)									
Total Lys	1.00	0.83	0.69	1.05	0.88	0.74	1.09	0.92	0.79
Total Thr	0.65	0.58	0.50	0.72	0.65	0.58	0.77	0.70	0.62
Total Trp	0.20	0.17	0.14	0.20	0.17	0.15	0.20	0.18	0.15
SID Lys	0.82	0.70	0.58	0.82	0.70	0.58	0.82	0.70	0.58
SID Thr	0.57	0.50	0.43	0.57	0.50	0.43	0.57	0.50	0.43
SID Trp	0.18	0.15	0.13	0.18	0.15	0.13	0.18	0.15	0.13
Cr. Protein	17.50	15.60	13.70	19.30	17.40	15.50	20.50	18.60	16.80
ME kcal/kg	3302	3320	3329	3311	3326	3335	3315	3337	3340
Ca	0.66	0.56	0.50	0.65	0.54	0.49	0.65	0.49	0.48
Total P	0.59	0.52	0.47	0.57	0.50	0.45	0.56	0.46	0.44
Avail P	0.29	0.23	0.19	0.29	0.23	0.19	0.29	0.20	0.19
Sodium	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.17	0.17
Chlorine	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28	0.28

Table 1 continued.

Treatment	**0% DDGS/10 % Glyc**			**15%DDGS/10% Glyc**			**25%DDGS/10% Glyc**		
Phase	1	2	3	1	2	3	1	2	3
Corn	629.0	681.0	731.0	516.0	568.0	617.0	440.0	494.0	541.0
SBM	246.0	198.0	150.0	211.0	163.0	116.0	188.0	140.0	93.0
DDGS	0.0	0.0	0.0	150.0	150.0	150.0	250.0	250.0	250.0
Glycerol	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Lysine	1.1	0.7	0.6	1.3	0.9	0.8	1.5	1.1	1.0
Dical Phos	12.0	9.2	7.3	7.5	4.7	2.8	4.5	0.0	0.0
Limestone	7.9	7.1	7.1	10.2	9.4	9.4	12.0	10.9	11.0
Salt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vit mix	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
TM Mix	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Se Mix	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Total	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
Calculated analysis, (% unless noted)									0.8
Total Lys	0.99	0.83	0.69	1.04	0.88	0.74	1.08	0.92	0.61
Total Thr	0.64	0.56	0.49	0.71	0.63	0.56	0.76	0.68	0.15
Total Trp	0.20	0.17	0.14	0.20	0.17	0.15	0.20	0.18	0.15
SID Lys	0.82	0.70	0.58	0.82	0.70	0.58	0.82	0.70	0.58
SID Thr	0.57	0.50	0.43	0.57	0.50	0.43	0.57	0.50	0.43
SID Trp	0.18	0.15	0.13	0.18	0.15	0.13	0.18	0.15	0.13
Cr. Protein	17.00	15.10	13.20	18.80	16.90	15.10	20.00	18.20	16.30
ME kcal/kg	3291	3307	3315	3298	3313	3322	3302	3324	3326
Ca	0.66	0.56	0.50	0.65	0.54	0.49	0.65	0.49	0.48
Total P	0.57	0.50	0.44	0.55	0.48	0.43	0.54	0.43	0.42
Avail P	0.29	0.23	0.19	0.29	0.23	0.19	0.28	0.19	0.19
Sodium	0.23	0.23	0.23	0.23	0.23	0.23	0.22	0.22	0.22
Chlorine	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36	0.36

Table 2. Performance of pigs fed DDGS and crude glycerol diets.

Treatments	**Units**								
DDGS	%	0	15	25	0	15	25		
Glycerol	%	0	0	0	10	10	10		
Item								**SEM**	***P*-value**
Start wt.	lb	87	87	87	88	86	88	1	0.90
End wt.	lb	279	271	274	275	270	278	3	0.33
Gain	lbs	191	184	187	187	184	190	3	0.46
ADFI	lbs	6.38	6.16	6.34	6.49	6.21	6.51	0.11	0.21
ADG	lb/day	2.28	2.19	2.23	2.22	2.18	2.27	0.04	0.46
Feed Efficiency	lb feed/lb gain	2.80	2.82	2.85	2.92	2.84	2.87	0.03	0.12
Backfat	in	0.92	0.83	0.81	0.94	0.91	0.94	0.04	0.06
Loin area	sq in.	7.73	7.20	7.29	7.46	7.30	7.21	0.16	0.22
Backfat 250	in.	0.81	0.76	0.74	0.84	0.84	0.83	0.03	0.06
Loin area 250	sq in.	7.22	6.85	6.88	7.04	6.95	6.75	0.14	0.23
Fat free lean	lb	108.6	104.9	106.4	105.6	103.9	105.2	1.6	0.39
Fat free lean	%	52.8	52.4	52.6	52.1	52.0	51.2	0.5	0.37
Lean gain	lb lean/day	0.90	0.86	0.88	0.86	0.85	0.86	0.02	0.42
Eff. of lean gain	lb feed/lb lean	7.08	7.20	7.21	7.53	7.33	7.57	0.15	0.17

Table 3. Percentage of fatty acids from fat samples of pigs fed DDGS and crude glycerol.[1]

Treatment	0%DDGS 0% Glyc	15%DDGS 0% Glyc	25%DDGS 0% Glyc	0%DDGS 10% Glyc	15%DDGS 10% Glyc	25%DDGS 10% Glyc		
Fatty Acid							**SEM**	***P*-value[2]**
C14:0	2.14	2.01	2.03	2.11	2.04	2.07	0.04	0.11
C16:0	30.33^{b}	28.59^{a}	27.91^{a}	30.03^{b}	28.64^{a}	28.42^{a}	0.22	.001
C16:1	3.37^{ab}	2.78^{d}	2.77^{d}	3.64^{a}	3.18^{bc}	2.93^{cd}	0.10	.001
C17:0	0.34	0.33	0.34	0.31	0.33	0.33	0.02	0.86
C17:1	0.31^{a}	0.29^{ab}	0.26^{b}	0.32^{a}	0.28^{ab}	0.27^{b}	0.01	0.004
C18:0	14.41^{c}	13.62^{bc}	12.53^{a}	13.67^{bc}	12.85^{ab}	12.46^{a}	0.25	.001
C18:1	38.9^{b}	37.2^{cd}	35.4^{c}	40.8^{a}	38.6^{bc}	37.1^{d}	0.4	.001
C18:2	9.6^{i}	14.5^{gh}	18.0^{f}	8.6^{i}	13.0^{h}	15.7^{g}	0.4	.001
C18:3	0.44^{bc}	0.49^{ab}	0.55^{a}	0.37^{c}	0.48^{ab}	0.53^{a}	0.02	.001
C20:4	0.18	0.21	0.22	0.18	0.18	0.21	0.01	0.06
SFA[3]	47.2^{c}	44.6^{b}	42.8^{a}	46.1^{c}	43.9^{ab}	43.3^{ab}	0.4	.001
MUFA[4]	42.6^{b}	40.3^{c}	38.4^{d}	44.8^{a}	42.1^{b}	40.3^{c}	0.5	.001
PUFA[5]	10.2^{i}	15.2^{gh}	18.8^{f}	9.1^{i}	14.0^{h}	16.4^{g}	0.4	.001

[abcde]Means in the same row with different superscripts differ $P < .01$.
[fghi]Means in the same row with different superscripts differ $P < .001$.
[1]Values reported are percentage of individual fatty acids of the total of the ten fatty acids analyzed.
[2]Overall treatment effect from the model.
[3]SFA = saturated fatty acids.
[4]MUFA = monounsaturated fatty acids.
[5]PUFA = polyunsaturated fatty acids.