EFFECTS OF INCREASING GLYCEROL AND DRIED DISTILLERS GRAINS WITH SOLUBLES ON THE GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING PIGS[1,2]

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Summary

A total of 1,160 barrows (PIC, initially 68.4 lb) were used in a 97-d study to determine the influence of glycerol and dried distillers grains with solubles (DDGS) on growing-finishing pig performance, carcass characteristics, and fat quality. Pigs were blocked by weight and randomly allotted to 1 of 6 dietary treatments with 7 replications per treatment. Pigs were fed corn-soybean meal-based diets arranged in a 2 × 3 factorial with main effects of glycerol (0, 2.5, or 5%) and DDGS (0 or 20%). Overall (d 0 to 97), there were no glycerol × DDGS interactions (*P* > 0.12) for growth performance, carcass characteristics, and carcass fat iodine value (IV). Increasing glycerol did not affect (*P* > 0.14) ADG or F/G. Adding 20% DDGS to the diet did not affect ADG. However, pigs fed diets with 20% added DDGS had greater (*P* < 0.02) ADFI resulting in poorer (*P* < 0.01) F/G than pigs fed diets with no DDGS. For carcass characteristics, pigs fed increasing glycerol tended to have increased (linear, *P* < 0.11) yield. Pigs fed diets with added DDGS had increased (*P* < 0.01) jowl fat, belly fat, and backfat IV compared with pigs fed diets with no DDGS. However, increasing dietary glycerol tended to decrease (linear, *P* < 0.11) backfat IV. In conclusion, feeding pigs 20% DDGS worsened F/G and increased carcass fat IV, whereas feeding glycerol did not influence growth performance but tended to improve carcass yield and reduce backfat IV.

Key words: dried distiller grains with solubles, glycerol, growing-finishing pig

Introduction

According to the National Biodiesel Board, in October 2007 there were 105 biodiesel production facilities operating and 77 facilities in the planning or construction stage in the United States. If all of these facilities were operational, the estimated U.S. biodiesel production capacity would exceed 2.5 billon gal. This level of production would produce nearly 1.3 million tons of glycerol, the primary coproduct of biodiesel production. There has been much interest in utilizing crude glycerol as a feed ingredient in animal diets. However, little is known about glycerol's nutritional value and its effect on carcass characteristics. Previous research has shown that the unsaturation index of carcass fat can be reduced when pigs are fed glycerol.

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Thus, combining glycerol with an ingredient high in unsaturated fat, such as dried distillers grains with solubles (DDGS), may improve carcass fat firmness.

In addition, research has shown that DDGS levels ranging from 0 to 20% of the diet could be fed without negatively affecting growth performance. Feeding DDGS has been shown to affect carcass quality and characteristics when fed to growing-finishing pigs. Specifically, feeding DDGS has been shown to reduce percent yield and carcass weight, increase carcass fat softness, and reduce belly firmness. Therefore, the objective of this trial was to evaluate the effect of dietary glycerol and DDGS on growing-finishing pig performance, carcass characteristics, and iodine value (IV) of belly fat, jowl fat, and backfat (BF).

Procedures

Procedures used in these experiments were approved by the Kansas State University (KSU) Institutional Animal Care and Use Committee. The experiment was conducted at a commercial research facility in southwest Minnesota. The facility had a totally slatted floor, and each pen was equipped with a 4-hole dry self-feeder and 1 cup waterer. The facility was a double-curtain-sided, deep-pit barn that operated on mechanical ventilation during the summer and on automatic ventilation during the winter. The experiment was conducted in late summer and fall of 2007.

A total of 1,160 barrows (PIC, 337 × 1050, initially 68.4 lb) were used in the 97-d study. Pigs were blocked by weight and randomly allotted to 1 of 6 dietary treatments with 7 pens per treatment. Each pen contained 27 to 28 barrows. Pigs were fed corn-soybean meal-based experimental diets (Tables 1, 2, 3, and 4) in meal form across 4 phases. The treatments were arranged in a 2 × 3 factorial with main effects of glycerol (0, 2.5, or 5%) and DDGS (0 or 20%). Multiple lots of glycerol from the same soybean biodiesel production facility (Minnesota Soybean Processors, Brewster, MN) were used in the trial. All experimental diets were balanced to maintain a constant standardized ileal digestible (SID) lysine:ME ratio within each phase. For both DDGS and glycerol, the NRC (1998) ME value of corn (1,551 kcal/lb) was used in diet formulation.

Pigs and feeders were weighed on d 0, 14, 28, 42, 56, 70, 84, and 97 to determine the response criteria of ADG, ADFI, and F/G. The pigs in this study were marketed in 2 different groups. First, on d 70, the barn was "topped," meaning the 2 heaviest pigs from each pen were visually selected, removed, and marketed. The remaining pigs were marketed on d 97.

At the end of the experiment, pigs from each pen were individually tattooed with pen number and shipped to the JBS Swift & Company processing plant (Worthington, MN). Standard carcass criteria of BW, loin and BF depth, HCW, lean percentage, and yield were collected. Fat-free lean index (FFLI) was also measured by using the equation:

$$50.767 + (0.035 \times HCW) - (8.979 \times BF).$$

Jowl, BF, and belly samples were collected from 2 randomly selected barrows from each pen from the d-97 marketing group to analyze fat for individual fatty acids. Samples were collected and frozen until further processing and analysis.

Iodine value was calculated from the following equation following AOCS (1998) procedures:

C16:1(0.95)+C18:1(0.86)+C18:2(1.732)+C18:3(2.616)+C20:1(0.785)+C22:1(0.723).

The fatty acids results are represented as a percentage of the total fatty acids in the sample.

Data were analyzed as a randomized complete block design by using the PROC MIXED procedure of SAS with pen as the experimental unit. Main effects and interactions between pigs fed glycerol and DDGS were tested. Linear and quadratic polynomial contrasts were used to determine the effects of increasing added glycerol.

Results

Overall (d 0 to 97), there were no glycerol × DDGS interactions ($P > 0.12$) for growth performance, carcass characteristics, and IV. Increasing dietary glycerol did not affect ($P >$ 0.14) any growth performance criteria (Table 5). Adding 20% DDGS to the diet did not affect ($P > 0.73$) ADG; however, pigs fed diets with added DDGS had greater ($P < 0.02$) ADFI and poorer ($P < 0.01$) F/G than pigs not fed DDGS. For carcass characteristics, increasing dietary glycerol tended to increase (linear, $P <$ 0.11) yield (Table 6). However, increasing glycerol in the diet did not affect ($P > 0.17$) carcass weight, carcass weight variation, BF depth, loin depth, FFLI, or lean percentage. Adding 20% DDGS to the diet did not affect ($P > 0.18$) any carcass characteristics. For carcass fat quality, pigs fed diets with added DDGS had increased ($P < 0.01$) linoleic acid, total polyunsaturated fats (PUFA), Unsaturated fatty acid:saturated fatty acids (UFA:SFA), and polyunsaturated:saturated fatty acids (PUFA:SFA) in jowl fat, belly fat, and BF compared with pigs fed diets with no DDGS (Table 7, 8, and 9). However, increasing glycerol tended to decrease (linear, $P <$ 0.08) linoleic acid, total PUFA, (linear, $P <$ 0.10) PUFA:SFA, and (linear, $P < 0.11$) IV in BF, with no change to jowl and belly fat IV (P > 0.24).

Discussion

Adding up to 5% glycerol to the diet did not influence growth performance. This response was expected because glycerol has been reported to have energy content similar to that of corn. However, in previous research at KSU, we observed reduced ADFI when finishing pigs were fed dietary glycerol; we believed this was due to decreased palatability as a result of prolonged storage. Because adding glycerol to diets did not influence ADFI in this study, palatability does not appear to be an issue with this glycerol source.

Contrary to previous research in this facility, the addition of DDGS to diets increased ADFI and worsened F/G. We hypothesize that the DDGS used in this trial had an actual ME value lower than our formulated value, which was the same as corn. Even though there was not a DDGS × glycerol interaction ($P = 0.12$), the 2% poorer F/G and greater ADFI for pigs fed diets with 20% DDGS was largely a result of responses when DDGS was added to diets containing glycerol. The F/G for the diets without glycerol was similar regardless whether DDGS was included in the diet (2.52 vs. 2.51).

Previous research has demonstrated that feeding DDGS results in decreased carcass yield and increased carcass fat IV. Although a decrease in yield was not observed in our trial, carcass fat did become softer when DDGS was added to the diet. Glycerol appeared to improve percent yield, which was not expected.

In conclusion, feeding pigs 20% DDGS worsened F/G and increased carcass fat IV, whereas feeding glycerol did not influence growth performance but tended to improve carcass yield and reduce backfat IV.

Table 1. Phase 1 diet composition (as-fed basis)[1]

	DDGS, %[2]					
	0			20		
Ingredient, %	0% glycerol	2.50% glycerol	5% glycerol	0% glycerol	2.50% glycerol	5% glycerol
Corn	68.18	65.47	62.77	55.16	52.46	49.75
Soybean meal (46.5% CP)	26.63	26.83	27.03	19.69	19.89	20.09
Glycerol	---	2.50	5.00	---	2.50	5.00
DDGS	---	---	---	20.00	20.00	20.00
Choice white grease	3.00	3.00	3.00	3.00	3.00	3.00
Monocalcium P, (21% P)	0.63	0.63	0.63	0.18	0.18	0.18
Limestone	0.85	0.85	0.85	1.13	1.13	1.13
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.08	0.08	0.08	0.08	0.08	0.08
Trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.10
Optiphos 2000[3]	0.03	0.03	0.03	0.03	0.03	0.03
L-Lysine HCl	0.15	0.15	0.15	0.30	0.30	0.30
DL-Methionine	0.01	0.02	0.02	---	---	---
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
SID[4] amino acids, %						
Lysine	0.98	0.98	0.98	0.98	0.98	0.98
Methionine:lysine	28	28	29	30	30	29
Met & Cys:lysine	57	57	57	61	61	60
Threonine:lysine	60	60	60	61	61	60
Tryptophan:lysine	19	19	19	18	18	18
SID Lysine:calorie ratio, g/Mcal ME	2.82	2.82	2.82	2.81	2.81	2.81
ME, kcal/lb	1,578	1,578	1,578	1,582	1,582	1,582
Total lysine, %	1.10	1.10	1.10	1.13	1.13	1.13
CP, %	18.33	18.20	18.06	19.57	19.44	19.30
Ca, %	0.55	0.55	0.55	0.55	0.55	0.55
P, %	0.51	0.50	0.49	0.47	0.46	0.46
Available P, %[5]	0.28	0.28	0.28	0.28	0.28	0.28

[1] Fed from 68 to 120 lb.
[2] Dried distillers grains with solubles.
[3] Provided per pound of diet: 227 phytase unit (FTU) of phytase.
[4] Standardized ileal digestible .
[5] Includes expected P release of .07% from added phytase.

Table 2. Phase 2 diet composition (as-fed basis)[1]

	DDGS, %[2]					
	0			20		
Ingredient, %	0% glycerol	2.50% glycerol	5% glycerol	0% glycerol	2.50% glycerol	5% glycerol
Corn	74.27	71.57	68.87	61.20	58.50	55.80
Soybean meal (46.5% CP)	20.66	20.86	21.06	13.72	13.92	14.12
Glycerol	---	2.50	5.00	---	2.50	5.00
DDGS	---	---	---	20.00	20.00	20.00
Choice white grease	3.00	3.00	3.00	3.00	3.00	3.00
Monocalcium P, (21% P)	0.55	0.55	0.55	0.13	0.13	0.13
Limestone	0.85	0.85	0.85	1.13	1.13	1.13
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.06	0.06	0.06	0.06	0.06	0.06
Trace mineral premix	0.08	0.08	0.08	0.08	0.08	0.08
Optiphos 2000[3]	0.03	0.03	0.03	0.03	0.03	0.03
L-Lysine HCl	0.15	0.15	0.15	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
SID[4] amino acids, %						
Lysine	0.83	0.83	0.83	0.83	0.83	0.83
Methionine:lysine	29	29	28	32	32	32
Met & Cys:lysine	60	59	58	66	65	64
Threonine:lysine	61	61	61	62	62	61
Tryptophan:lysine	19	19	19	17	17	17
SID Lysine:calorie ratio, g/Mcal ME	2.38	2.38	2.38	2.38	2.38	2.38
ME, kcal/lb	1,580	1,580	1,580	1,585	1,585	1,585
Total lysine, %	0.93	0.93	0.93	0.97	0.96	0.96
CP, %	16.06	15.93	15.79	17.31	17.17	17.04
Ca, %	0.52	0.52	0.52	0.52	0.52	0.52
P, %	0.47	0.46	0.45	0.43	0.43	0.42
Available P, %[5]	0.25	0.24	0.24	0.25	0.25	0.25

[1] Fed from 120 to 170 lb.
[2] Dried distillers grains with solubles.
[3] Provided per pound of diet: 227 phytase unit (FTU) of phytase.
[4] Standardized ileal digestible.
[5] Includes expected P release of .07% from added phytase.

Table 3. Phase 3 diet composition (as-fed basis)[1]

	DDGS, %[2]					
	0			20		
Ingredient, %	0% glycerol	2.50% glycerol	5% glycerol	0% glycerol	2.50% glycerol	5% glycerol
Corn	78.67	75.97	73.27	64.12	61.42	58.72
Soybean meal (46.5% CP)	16.28	16.48	16.68	10.90	11.10	11.30
Glycerol	---	2.50	5.00	---	2.50	5.00
DDGS	---	---	---	20.00	20.00	20.00
Choice white grease	3.00	3.00	3.00	3.00	3.00	3.00
Monocalcium P, (21% P)	0.55	0.55	0.55	0.10	0.10	0.10
Limestone	0.85	0.85	0.85	1.13	1.13	1.13
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.05	0.05	0.05	0.05	0.05	0.05
Trace mineral premix	0.07	0.07	0.07	0.07	0.07	0.07
Optiphos 2000[3]	0.03	0.03	0.03	0.03	0.03	0.03
L-Lysine HCl	0.15	0.15	0.15	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
SID[4] amino acids, %						
Lysine	0.72	0.72	0.72	0.72	0.72	0.72
Methionine:lysine	31	30	30	35	35	35
Met & Cys:lysine	63	62	61	72	71	71
Threonine:lysine	62	62	62	66	66	65
Tryptophan:lysine	19	19	19	17	17	17
SID Lysine:calorie ratio, g/Mcal ME	2.06	2.06	2.06	2.06	2.06	2.06
ME, kcal/lb	1,582	1,582	1,582	1,586	1,586	1,586
Total lysine, %	0.81	0.81	0.81	0.85	0.85	0.85
CP, %	14.40	14.27	14.13	16.20	16.06	15.93
Ca, %	0.50	0.50	0.50	0.51	0.51	0.51
P, %	0.45	0.44	0.44	0.42	0.41	0.41
Available P, %[5]	0.23	0.23	0.23	0.23	0.23	0.23

[1] Fed from 170 to 220 lb.
[2] Dried distillers grains with solubles.
[3] Provided per pound of diet: 227 phytase unit (FTU) of phytase.
[4] Standardized ileal digestible.
[5] Includes expected P release of .07% from added phytase.

Table 4. Phase 4 diet composition (as-fed basis)[1]

	DDGS, %[2]					
	0			20		
Ingredient, %	0% glycerol	2.50% glycerol	5% glycerol	0% glycerol	2.50% glycerol	5% glycerol
Corn	80.64	77.93	75.23	66.09	63.39	60.69
Soybean meal (46.5% CP)	14.29	14.50	14.70	8.91	9.11	9.31
Glycerol	---	2.50	5.00	---	2.50	5.00
DDGS	---	---	---	20.00	20.00	20.00
Choice white grease	3.00	3.00	3.00	3.00	3.00	3.00
Monocalcium P, (21% P)	0.60	0.60	0.60	0.15	0.15	0.15
Limestone	0.85	0.85	0.85	1.13	1.13	1.13
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.04	0.04	0.04	0.04	0.04	0.04
Trace mineral premix	0.05	0.05	0.05	0.05	0.05	0.05
Optiphos 2000[3]	0.03	0.03	0.03	0.03	0.03	0.03
L-Lysine HCl	0.15	0.15	0.15	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
SID[4] amino acids, %						
Lysine	0.64	0.64	0.64	0.64	0.64	0.64
Methionine:lysine	31	31	31	37	36	36
Met & Cys:lysine	65	64	63	75	74	73
Threonine:lysine	63	62	62	67	67	66
Tryptophan:lysine	19	19	18	17	17	17
SID Lysine:calorie ratio, g/Mcal ME	1.92	1.92	1.92	1.92	1.92	1.92
ME, kcal/lb	1,582	1,582	1,582	1,586	1,586	1,586
Total lysine, %	0.76	0.76	0.76	0.79	0.79	0.79
CP, %	13.65	13.51	13.37	15.44	15.31	15.17
Ca, %	0.51	0.51	0.51	0.51	0.51	0.51
P, %	0.45	0.44	0.44	0.42	0.41	0.41
Available P, %[5]	0.22	0.22	0.22	0.22	0.22	0.22

[1] Fed from 220 to 273 lb.
[2] Dried distillers grains with solubles.
[3] Provided per pound of diet: 227 phytase unit (FTU) of phytase.
[4] Standardized ileal digestible.
[5] Includes expected P release of .07% from added phytase.

Table 5. Influence of glycerol and DDGS[1] on growing-finishing pig performance[2]

	0% DDGS			0% DDGS							Contrasts, *P* <	
	Glycerol, %			Glycerol, %							Glycerol	
Item	0	2.50	5	0	2.50	5	SE	D×G	DDGS	Glycerol	Linear	Quadratic
d 0 to 97												
Initial wt, lb	68.0	68.2	69.0	68.2	68.9	68.2	2.46	0.95	0.98	0.98	0.84	0.94
ADG, lb	2.14	2.11	2.12	2.14	2.12	2.13	0.02	0.99	0.73	0.44	0.38	0.35
ADFI, lb	5.37	5.28	5.30	5.39	5.41	5.53	0.06	0.29	0.02	0.59	0.63	0.37
F/G	2.51	2.50	2.50	2.52	2.56	2.60	0.02	0.12	0.01	0.31	0.14	0.72
Final wt, lb	273.5	272.0	271.9	273.8	273.8	272.1	3.20	0.96	0.76	0.87	0.60	0.98
Removals	6	7	6	6	10	6						

[1] Dried distillers grain with solubles.
[2] A total of 1,160 pigs (initially 68.4 lb.) were used in a 97-d experiment with 27 to 28 pigs per pen and 7 replications per treatment.

Table 6. Influence of glycerol and DDGS[1] on grow-finish pig carcass characteristics for pigs marketed on d 97[2,3]

	0% DDGS			0% DDGS							Contrasts, *P* <	
	Glycerol, %			Glycerol, %							Glycerol	
Item	0	2.50	5	0	2.50	5	SE	D×G	DDGS	Glycerol	Linear	Quadratic
Carcass wt, lb	205.3	204.7	203.1	201.6	202.5	204.3	2.4	0.63	0.45	0.99	0.92	0.98
Carcass wt CV, %	9.0	9.4	9.2	8.8	8.1	8.9	0.67	0.67	0.35	0.94	0.82	0.76
Yield, %	75.1	75.5	75.7	74.5	75.9	75.7	0.47	0.56	0.93	0.17	0.11	0.37
Backfat, in	0.78	0.78	0.78	0.76	0.75	0.77	0.02	0.87	0.18	0.81	0.86	0.54
Loin depth, in	2.48	2.47	2.39	2.40	2.41	2.44	0.03	0.12	0.27	0.77	0.57	0.62
FFLI, %[4]	49.2	49.1	49.1	49.3	49.4	49.3	0.24	0.93	0.32	0.96	0.81	0.89
Lean, %	54.3	54.3	54.2	54.4	54.6	54.4	0.33	0.95	0.43	0.86	0.76	0.64

[1] Dried distillers grain with solubles.
[2] A total of 1,160 pigs (initially 68.4 lb.) were used in a 97-d experiment with 27 to 28 pigs per pen and 7 replications per treatment.
[3] A total of 1,035 pigs were marketed with 23 to 26 pigs per pen.
[4] Fat-free lean index.

Table 7. Influence of glycerol and DDGS[1] on grow-finish pig jowl fat quality[2,3]

	0% DDGS			0% DDGS							Contrasts, $P <$	
	Glycerol, %			Glycerol, %							Glycerol	
Item	0	2.50	5	0	2.50	5	SE	D×G	DDGS	Glycerol	Linear	Quadratic
Myristic acid (14:0), %	1.32	1.48	1.46	1.31	1.30	1.35	0.04	0.10	0.005	0.06	0.03	0.35
Palmitic acid (16:0), %	21.40	22.10	22.14	20.78	20.91	20.89	0.29	0.51	0.0002	0.27	0.16	0.43
Palmitoleic acid (16:1), %	2.75	3.02	2.97	2.48	2.44	2.46	0.12	0.40	0.0001	0.61	0.43	0.55
Margaric acid (17:0), %	0.53	0.49	0.56	0.53	0.50	0.53	0.03	0.73	0.63	0.14	0.52	0.07
Stearic acid (18:0), %	9.30	8.95	9.22	8.93	9.09	8.75	0.26	0.47	0.29	0.88	0.63	0.89
Oleic acid (18:1c9), %	41.28	42.17	41.21	39.50	40.19	39.99	0.45	0.63	0.0001	0.29	0.89	0.12
Vaccenic acid (18:1n7), %	3.29	3.60	3.45	2.99	3.03	3.02	0.08	0.28	0.0001	0.13	0.25	0.10
Linoleic acid (18:2n6), %	14.48	13.04	13.61	18.63	17.04	17.70	0.68	0.99	0.0001	0.11	0.20	0.09
α-linolenic acid (18:3n3), %	0.71	0.65	0.69	0.73	0.73	0.72	0.73	0.48	0.11	0.64	0.64	0.42
γ-linolenic acid (18:3n6), %	0.47	0.30	0.36	0.23	0.40	0.33	0.47	0.57	0.68	0.99	0.99	0.99
Arachidic acid (20:0), %	0.35	0.31	0.36	0.26	0.33	0.29	0.06	0.60	0.35	0.92	0.69	0.89
Eicosadienoic acid (20:2), %	0.85	0.76	0.79	0.95	0.97	0.97	0.03	0.23	0.0001	0.57	0.51	0.41
Arachidonic acid (20:4n6), %	0.12	0.12	0.10	0.12	0.12	0.12	0.009	0.22	0.42	0.55	0.33	0.64
Other fatty acids, %	1.57	1.48	1.52	1.20	1.46	1.37	0.20	0.66	0.28	0.92	0.79	0.76
Total SFA, %[4]	33.39	33.79	34.22	32.22	32.58	32.25	0.47	0.64	0.0007	0.61	0.37	0.69
Total MUFA, %[5]	49.15	50.69	49.46	46.55	47.40	47.24	0.50	0.56	0.0001	0.08	0.36	0.04
Total PUFA, %[6]	17.46	15.52	16.32	21.23	20.02	20.51	0.72	0.88	0.0001	0.11	0.21	0.09
Total *trans* fatty acids, %[7]	0.61	0.55	0.60	0.41	0.58	0.52	0.13	0.69	0.45	0.90	0.70	0.79
UFA:SFA ratio[8]	2.00	1.96	1.93	2.11	2.08	2.11	0.04	0.70	0.0007	0.66	0.41	0.71
PUFA:SFA ratio[9]	0.53	0.46	0.48	0.66	0.62	0.64	0.03	0.91	0.0001	0.19	0.23	0.17
Iodine value, g/100 g[10]	70.5	68.6	68.9	74.1	73.3	74.0	0.88	0.69	0.01	0.33	0.36	0.24

[1] Dried distillers grain with solubles.
[2] A total of 1,160 pigs (initially 68.4 lb.) were used in a 97-d experiment with 27 to 28 pigs per pen and 7 replications per treatment.
[3] A total of 84 pigs were used for fat sample collection with 2 pigs per pen and 7 replications per treatment.
[4] Total saturated fatty acids = {[C8:0] + [C10:0] + [C12:0] + [C14:0] + [C16:0] + [C17:0] + [C18:0] + [C20:0] + [C22:0] + [C24:0]}, where the brackets indicate concentration.
[5] Total monounsaturated fatty acids = {[C14:1] + [C16:1] + [C18:1c9] + [C18:1n7] + [C20:1] + [C24:1]}, where the brackets indicate concentration.
[6] Total polyunsaturated fatty acids = {[C18:2n6] + [C18:3n3] + [C18:3n6] + [C20:2] + [C20:4n6]}, where the brackets indicate concentration.
[7] Total *trans* fatty acids = {[C18:1t] + [C18:2t] + [C18:3t]}, where the brackets indicate concentration.
[8] UFA:SFA ratio = [Total MUFA + Total PUFA] / Total SFA.
[9] PUFA:SFA ratio = Total PUFA / Total SFA.
[10] Calculated as IV=[C16:1] × 0.95 + [C18:1] × 0.86 + [C18:2] × 1.732 +[C18:3] × 2.616 + [C20:1] × 0.785+[C22:1] × 0.723, where the brackets indicate concentration (AOCS, 1998).

Table 8. Influence of glycerol and DDGS[1] on grow-finish pig belly fat quality[2,3]

	0% DDGS			0% DDGS							Contrasts, $P <$	
	Glycerol, %			Glycerol, %							Glycerol	
Item	0	2.50	5	0	2.50	5	SE	D×G	DDGS	Glycerol	Linear	Quadratic
Myristic acid (14:0), %	1.32	1.39	1.43	1.26	1.24	1.27	0.04	0.26	0.0002	0.22	0.09	0.82
Palmitic acid (16:0), %	23.20	23.12	23.62	21.60	21.95	21.57	0.33	0.42	0.0001	0.84	0.56	0.89
Palmitoleic acid (16:1), %	2.16	2.26	2.37	2.01	1.95	1.93	0.08	0.19	0.0001	0.75	0.47	0.85
Margaric acid (17:0), %	0.54	0.53	0.57	0.54	0.49	0.55	0.02	0.76	0.30	0.11	0.35	0.06
Stearic acid (18:0), %	11.81	11.30	11.55	10.32	10.90	10.49	0.35	0.31	0.002	0.98	0.90	0.85
Oleic acid (18:1c9), %	39.09	39.49	39.21	37.16	38.41	37.84	0.36	0.35	0.0001	0.40	0.79	0.18
Vaccenic acid (18:1n7), %	2.72	2.83	2.85	2.53	2.51	2.51	0.04	0.32	0.0001	0.59	0.33	0.76
Linoleic acid (18:2n6), %	14.51	14.08	13.52	19.88	17.86	18.82	0.66	0.42	0.0001	0.16	0.14	0.23
α-linolenic acid (18:3n3), %	0.65	0.66	0.65	0.72	0.68	0.71	0.03	0.53	0.04	0.90	0.83	0..68
γ-linolenic acid (18:3n6), %	0.25	0.33	0.29	0.22	0.25	0.29	0.12	0.94	0.67	0.87	0.64	0.79
Arachidic acid (20:0), %	0.34	0.35	0.36	0.29	0.33	0.32	0.04	0.91	0.25	0.75	0.55	0.66
Eicosadienoic acid (20:2), %	0.78	0.77	0.75	0.94	0.90	0.98	0.03	0.15	0.0001	0.54	0.96	0.28
Arachidonic acid (20:4n6), %	0.10	0.12	0.11	0.11	0.10	0.11	0.007	0.20	0.51	0.99	0.86	0.97
Other fatty acids, %	1.12	1.32	1.28	1.11	1.13	1.21	0.12	0.76	0.37	0.56	0.32	0.69
Total SFA, %[4]	37.61	37.12	38.00	34.42	35.30	34.59	0.60	0.38	0.0001	0.90	0.65	0.93
Total MUFA, %[5]	45.60	46.32	46.12	43.18	44.43	43.91	0.39	0.55	0.0001	0.35	0.41	0.20
Total PUFA, %[6]	16.79	16.56	15.87	22.40	20.27	21.50	0.72	0.33	0.0001	0.25	0.22	0.26
Total *trans* fatty acids, %[7]	0.43	0.55	0.52	0.42	0.48	0.51	0.10	0.96	0.72	0.57	0.38	0.57
UFA:SFA ratio[8]	1.67	1.70	1.63	1.91	1.84	1.90	0.05	0.41	0.0001	0.89	0.66	0.86
PUFA:SFA ratio[9]	0.45	0.45	0.42	0.65	0.58	0.63	0.03	0.35	0.0001	0.37	0.30	0.35
Iodine value, g/100 g[10]	66.7	66.8	65.5	73.6	71.5	72.9	1.07	0.40	0.01	0.60	0.40	0.58

[1] Dried distillers grain with solubles.
[2] A total of 1,160 pigs (initially 68.4 lb.) were used in a 97-d experiment with 27 to 28 pigs per pen and 7 replications per treatment.
[3] A total of 84 pigs were used for fat sample collection with 2 pigs per pen and 7 replications per treatment.
[4] Total saturated fatty acids = {[C8:0] + [C10:0] + [C12:0] + [C14:0] + [C16:0] + [C17:0] + [C18:0] + [C20:0] + [C22:0] + [C24:0]}, where the brackets indicate concentration.
[5] Total monounsaturated fatty acids = {[C14:1] + [C16:1] + [C18:1c9] + [C18:1n7] + [C20:1] + [C24:1]}, where the brackets indicate concentration.
[6] Total polyunsaturated fatty acids = {[C18:2n6] + [C18:3n3] + [C18:3n6] + [C20:2] + [C20:4n6]}, where the brackets indicate concentration.
[7] Total *trans* fatty acids = {[C18:1t] + [C18:2t] + [C18:3t]}, where the brackets indicate concentration.
[8] UFA:SFA ratio = [Total MUFA + Total PUFA] / Total SFA.
[9] PUFA:SFA ratio = Total PUFA / Total SFA.
[10] Calculated as IV=[C16:1] × 0.95 + [C18:1] × 0.86 + [C18:2] × 1.732 +[C18:3] × 2.616 + [C20:1] × 0.785+[C22:1] × 0.723, where the brackets indicate concentration (AOCS, 1998).

Table 9. Influence of glycerol and DDGS[1] on grow-finish pig backfat quality[2,3]

	0% DDGS			0% DDGS							Contrasts, $P <$	
	Glycerol, %			Glycerol, %							Glycerol	
Item	0	2.50	5	0	2.50	5	SE	D×G	DDGS	Glycerol	Linear	Quadratic
Myristic acid (14:0), %	1.36	1.44	1.46	1.31	1.27	1.34	0.04	0.30	0.0006	0.19	0.08	0.70
Palmitic acid (16:0), %	23.62	23.78	24.54	22.12	22.38	22.40	0.34	0.51	0.0001	0.22	0.09	0.78
Palmitoleic acid (16:1), %	2.24	2.28	2.36	1.92	1.95	1.95	0.09	0.81	0.0001	0.69	0.40	0.98
Margaric acid (17:0), %	0.54	0.54	0.57	0.54	0.50	0.54	0.03	0.76	0.34	0.44	0.65	0.23
Stearic acid (18:0), %	11.97	11.70	12.25	10.86	11.11	10.93	0.38	0.63	0.003	0.87	0.66	0.78
Oleic acid (18:1c9), %	38.55	39.01	38.89	36.62	37.99	37.23	0.35	0.43	0.0001	0.07	0.26	0.04
Vaccenic acid (18:1n7), %	2.69	2.78	2.76	2.41	2.46	2.46	0.05	0.95	0.0001	0.41	0.30	0.41
Linoleic acid (18:2n6), %	14.59	14.10	12.98	19.99	18.03	18.80	0.76	0.44	0.0001	0.16	0.08	0.44
α-linolenic acid (18:3n3), %	0.65	0.64	0.59	0.70	0.66	0.68	0.03	0.45	0.02	0.37	0.16	0.91
γ-linolenic acid (18:3n6), %	0.19	0.16	0.17	0.13	0.14	0.16	0.03	0.64	0.29	0.90	0.97	0.64
Arachidic acid (20:0), %	0.33	0.29	0.31	0.24	0.25	0.25	0.02	0.64	0.003	0.76	0.80	0.49
Eicosadienoic acid (20:2), %	0.74	0.73	0.68	0.88	0.86	0.89	0.02	0.18	0.0001	0.51	0.25	0.98
Arachidonic acid (20:4n6), %	0.10	0.09	0.09	0.11	0.11	0.09	0.008	0.40	0.21	0.32	0.15	0.70
Other fatty acids, %	1.13	1.18	1.03	0.96	1.06	1.01	0.06	0.45	0.05	0.25	0.70	0.11
Total SFA, %[4]	38.24	38.17	39.55	35.44	35.89	35.84	0.66	0.56	0.0001	0.42	0.21	0.69
Total MUFA, %[5]	44.98	45.60	45.52	42.33	43.85	43.10	0.41	0.53	0.0001	0.05	0.12	0.05
Total PUFA, %[6]	16.78	16.22	14.93	22.23	20.26	21.06	0.82	0.44	0.0001	0.16	0.08	0.48
Total *trans* fatty acids, %[7]	0.38	0.40	0.33	0.30	0.37	0.34	0.04	0.52	0.31	0.42	0.99	0.20
UFA:SFA ratio[8]	1.62	1.62	1.53	1.83	1.80	1.80	0.05	0.63	0.0001	0.46	0.24	0.74
PUFA:SFA ratio[9]	0.44	0.43	0.38	0.63	0.57	0.59	0.03	0.52	0.0001	0.23	0.10	0.64
Iodine value, g/100 g[10]	66.1	65.7	63.5	73.1	71.0	71.8	1.22	0.48	0.01	0.27	0.11	0.79

[1] Dried distillers grain with solubles.
[2] A total of 1,160 pigs (initially 68.4 lb.) were used in a 97-d experiment with 27 to 28 pigs per pen and 7 replications per treatment.
[3] A total of 84 pigs were used for fat sample collection with 2 pigs per pen and 7 replications per treatment.
[4] Total saturated fatty acids = {[C8:0] + [C10:0] + [C12:0] + [C14:0] + [C16:0] + [C17:0] + [C18:0] + [C20:0] + [C22:0] + [C24:0]}, where the brackets indicate concentration.
[5] Total monounsaturated fatty acids = {[C14:1] + [C16:1] + [C18:1c9] + [C18:1n7] + [C20:1] + [C24:1]}, where the brackets indicate concentration.
[6] Total polyunsaturated fatty acids = {[C18:2n6] + [C18:3n3] + [C18:3n6] + [C20:2] + [C20:4n6]}, where the brackets indicate concentration.
[7] Total *trans* fatty acids = {[C18:1t] + [C18:2t] + [C18:3t]}, where the brackets indicate concentration.
[8] UFA:SFA ratio = [Total MUFA + Total PUFA] / Total SFA.
[9] PUFA:SFA ratio = Total PUFA / Total SFA.
[10] Calculated as IV=[C16:1] × 0.95 + [C18:1] × 0.86 + [C18:2] × 1.732 +[C18:3] × 2.616 + [C20:1] × 0.785+[C22:1] × 0.723, where the brackets indicate concentration (AOCS, 1998).