Effects of added fat on growth performance of finishing pigs sorted by initial weight[1]

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ABSTRACT: Two studies were conducted to determine whether dietary fat fed to pigs of different weight categories differentially influences growth performance. Both experiments were conducted in a 2 × 3 factorial arrangement with main effects of dietary fat addition (0 or 6% choice white grease) and sort weight category (HEAVY, LIGHT, or MIXED). In experiment 1, 1,032 pigs (initially 30.7 kg) were individually weighed and sorted into two body weight (BW) groups with one group consisting of pigs greater than median BW and the other group less than median BW. Pens were then formed by randomly selecting pigs: 1) only from heavy group (HEAVY), 2) only from light group (LIGHT), or 3) from both heavy and light groups to create a normal distribution around barn BW mean (simulation of unsorted pigs; MIXED). In experiment 2, 1,176 pigs (initially 35.1 kg) were visually sorted into BW groups and assigned to HEAVY, LIGHT, and MIXED pen weight categories. Overall in experiment 1, adding 6% dietary fat increased average daily gain (ADG) of LIGHT pigs, but not HEAVY pigs (HEAVY vs. LIGHT × fat interaction, $P = 0.03$), but increased ($P < 0.05$) ADG regardless of sort category in experiment 2. In both experiments, HEAVY pigs had greater ($P < 0.05$) overall ADG and average daily feed intake (ADFI), but decreased ($P < 0.05$) G:F compared with LIGHT pigs. However, when HEAVY and LIGHT treatment groups were combined, growth performance and carcass characteristics were similar to MIXED pigs. Sorting decreased coefficient of variation (CV) of final BW but did not affect CV of ADG. In conclusion, because adding fat to the diets of lightweight pigs improved ADG in both experiments, dietary fat could be used selectively in the barn to increase the weight of the lightest 50% of the pigs. However, the sorting pigs into light and heavy weight groups did not improve growth performance or carcass characteristics.

Key words: dietary fat, growth, sorting, pigs, weight variation

Transl. Anim. Sci. 2020.4:307–315
doi: 10.1093/tas/txz162

INTRODUCTION

The competitiveness of the modern swine industry dictates that feed, labor, and facilities must be utilized efficiently. The importance of growth rate has increased with the adoption of all-in, all-out technology to improve facility utilization

[1]Contribution no. 20-034-J from Kansas Agricultural Experiment Station, Manhattan 66506. The authors would like to thank New Horizon Farms, Pipestone, MN, for providing facilities and support for these experiments.

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Received August 2, 2019.
Accepted October 4, 2019.

and increase profitability (Ice et al., 1999; Losinger et al., 1999, Patience et al., 2004). During the marketing period of all-in, all-out finishing facilities, normal distribution of the population dictates that lightweight pigs, or those weighing below packer minimum weight standards, will be present. Packer matrices impose large discounts for lightweight pigs (Payne et al., 1999; Patience et al., 2004). Therefore, any technology or management technique that reduces the number of lightweight pigs will result in a greater economic return. There are two methods to decrease the number of lightweight pigs without increasing days on feed. The first method is to reduce the amount of variation within the population. However, reducing the amount of variation is difficult to achieve (van Barneveld and Hewitt, 2016; López-Vergé et al., 2018). A second method of reducing variation is by increasing the growth rate of the lightest pigs, thus shifting this portion of the population to heavier weights. The addition of dietary fat has been shown to increase average daily gain (ADG) in commercial field conditions (Benz et al., 2011; Kellner et al., 2014; Stephenson et al., 2016). Thus, our objective was to determine whether adding dietary fat to diets of the lightest 50% of the population in a finishing barn would result in ADG similar to the heaviest pigs fed diets without added fat. The second objective was to determine if adding dietary fat influenced the CV for ADG within heavy- or lightweight pigs.

MATERIALS AND METHODS

The Kansas State University Institutional Animal Care and Use Committee approved all experimental protocols used in this study.

General

In both experiments, diets were prepared in three phases and fed in meal form (Table 1). Amino acid levels were set at requirement estimates that were previously demonstrated to maximize performance for pigs of the same genetic line in the same facilities (Main et al., 2008). A constant lysine to metabolizable energy (ME) ratio was maintained within each phase with the ratios of 3.1, 2.5, and 2.6 g lysine/Mcal ME in the three phases, respectively. Both experiments were conducted in 12.5 × 76.2 m barns in southwestern Minnesota. The barns contained 48 pens (3.05 × 5.49 m). Each pen contained one 4-hole dry feeder and two cup waterers. The curtain-sided barn has a deep pit, with completely slatted floors, and operates on natural ventilation during the summer and mechanically assisted ventilation during the winter. Treatments were arranged as a 2 × 3 factorial. Main effects included dietary fat addition (0 or 6% added choice white grease) and sorting of pigs into three weight categories (HEAVY, LIGHT, or MIXED).

Experiment 1

This experiment began in the spring with 1,032 gilts (L337 × 1050, PIC, Hendersonville, TN; initially 30.7 kg). Pigs were individually tagged with 3 cm round electronic identification tags (EID) with unique 15-digit code. Pigs were weighed individually and divided into two body weight (BW) groups; the heavy group consisted of pigs with BW greater than barn median, and the light group contained pigs less than median BW. Pens were then formed by selecting pigs: 1) only from heavy group (HEAVY), 2) only from light group (LIGHT), or 3) from both heavy and light groups to create a normal distribution around barn BW mean (MIXED). There were 24 or 25 pigs per pen and 7 pens per treatment. Pens of pigs were weighed and feed disappearance determined approximately every 14 d during the entire experiment. Individual pig weights were recorded at the beginning, approximately 8 wk after the start of experiment (day 56), approximately 3 wk before the conclusion (day 88), and at the conclusion of the experiment (day 109). In conjunction with the third individual weigh period, two heaviest pigs from HEAVY pens and the heaviest pig from MIXED pens were visually selected, removed, and marketed as per commercial production practices. At the end of the experiment, pigs from each pen were individually tattooed and shipped to a commercial processing plant (Swift, Inc., Worthington, MN) where standard carcass criteria (loin and fat depth, hot carcass weight, dressing percentage, lean percentage, and fat-free-lean index) were measured.

Experiment 2

This experiment started in the subsequent fall with 1,176 gilts (L337 × 1050, PIC, Hendersonville, TN; initially 35.1 kg). Pigs were individually tagged with 3 cm round EID tags as in experiment 1. Pigs were then visually sorted into weight groups around the population mean and then sorted into weight treatments (HEAVY, LIGHT, and MIXED) with 28 pigs per pen. For the duration of the experiment, pens of pigs were weighed and feed disappearance determined every 14 d. Individual pig weights were recorded at the beginning (after allotment), approximately 7 wk

Table 1. Diet composition (experiment 1 and 2; as-fed basis)

	Phase 1[1]		Phase 2[2]		Phase 3[3]	
Item added fat:	0%	6%	0%	6%	0%	6%
Ingredient, %						
Corn	68.70	58.64	75.82	66.26	75.28	65.75
Soybean meal, 46.5% CP	28.92	32.91	22.02	25.49	22.73	26.18
Choice white grease	—	6.00	—	6.00	—	6.00
L-lysine HCl	0.15	0.15	0.15	0.15	0.15	0.15
Monocalcium P, 21% P	0.73	0.85	0.60	0.75	0.50	0.58
Ground limestone	0.85	0.80	0.80	0.80	0.80	0.80
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix[4]	0.15	0.15	0.13	0.10	0.08	0.08
Trace mineral premix[5]	0.15	0.15	0.13	0.10	0.08	0.08
Ractopamine HCl	—	—	—	—	0.03	0.03
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrient composition						
Standardized ileal digestible lysine, %	1.01	1.09	0.84	0.91	0.86	0.93
Metabolizable energy (ME), Mcal/kg	3.29	3.57	3.31	3.58	3.31	3.59
Lysine:ME, g/Mcal	3.06	3.06	2.55	2.55	2.59	2.59
Crude protein, %	19.60	20.68	16.90	17.77	17.19	18.05
Calcium, %	0.61	0.63	0.55	0.57	0.51	0.54
Phosphorous, %	0.54	0.57	0.48	0.51	0.46	0.48

[1]Phase 1 diets fed day 0 to 42 in experiment 1 and day 0 to 49 in experiment 2.

[2]Phase 2 diets fed day 42 to 88 in experiment 1 and day 49 to 81 in experiment 2.

[3]Phase 3 diets fed 88 to 109 in experiment 1 and day 81 to 95 in experiment 2.

[4]Vitamin premix provided per kg of complete feed: 27,558 IU vitamin A, from vitamin A 650; 4,133.6 IU vitamin D3 from vitamin D3 400; 110.2 IU vitamin E from vitamin E 50%; 11.0 mg vitamin K from MPB 100%; 0.10 mg B12 from vitamin B12 600; 24.8 mg riboflavin from riboflavin 95%; 82.7 mg pantothenic acid from *d*-Cal Pan 100% and 137.8 mg of niacin from niacin 99.5%.

[5]Trace mineral premix provided per kg of complete feed:165.3 g Zn from ZnO; 165.3 g Fe from $FeSO_4$; 39.7 g Mn from MnO; 16.5 g Cu from $CuSO_4$; 0.30 mg I from CaI_2O_6; and 0.30 mg Se from $NaSeO_4$.

after the start of experiment (day 49), approximately 3 wk before the conclusion (day 81), and at the conclusion of the experiment (day 95). Similar to the first experiment, the two heaviest pigs from HEAVY pens and the heaviest pig from MIXED pens were visually selected and removed at the third weigh period. At the end of the experiment, pigs from each pen were individually tattooed and shipped to the same processing plant where the standard carcass criteria were measured as in experiment 1.

Statistical Analysis

Data from both experiments were analyzed as a completely randomized design with pen as the experimental unit. Analysis of variance was performed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Single degree-of-freedom contrasts were used to determine the main effects of dietary fat addition and sort weight category as well as their interaction on growth performance. Preplanned nonorthogonal contrasts were also used to compare the sorted (HEAVY and LIGHT pens combined) vs. unsorted (MIXED) treatments, HEAVY vs. LIGHT treatments, and their interaction with dietary fat addition.

RESULTS

Experiment 1

The addition of fat to diets increased ($P < 0.05$) ADG from day 0 to 56 (0.72 vs. 0.70 kg/d) and from day 56 to 88 (0.86 vs. 0.83 kg/d; Table 2). From day 88 to 109 and during the overall study, there was a HEAVY vs. LIGHT × fat interaction ($P < 0.05$) for ADG. This occurred because ADG increased when fat was added to diets for LIGHT pigs, but not when fat was added to diets for HEAVY pigs. Adding fat to the diet reduced ($P < 0.01$) average daily feed intake (ADFI) and increased ($P < 0.01$) gain:feed ratio (G:F) during each period. A HEAVY vs. LIGHT × fat interaction ($P < 0.05$) for ADFI was observed from day 88 to 109 and the overall study. This appeared to be the result of a greater reduction in ADFI for HEAVY vs. LIGHT pigs when fat was added ($P < 0.01$).

The addition of fat to diets increased ($P = 0.03$) day 88 BW (99.4 vs. 97.6 kg) but had no effect on

Table 2. Effects of added fat and initial sort on growth performance of finishing pigs (experiment 1)[1]

Added dietary fat:	0%			6%			Main effect *P*-value				Interaction *P*-value	
Sort category:[2]	HEAVY	LIGHT	MIXED	HEAVY	LIGHT	MIXED	SEM	Fat	HEAVY vs. LIGHT	Sorted[3] vs. MIXED	HEAVY vs. LIGHT by fat	Sorted vs. MIXED by fat
Average daily gain, kg												
day 0 to 56	0.75	0.64	0.70	0.77	0.69	0.71	0.014	0.04	0.01	0.42	0.27	0.45
day 56 to 88	0.85	0.82	0.82	0.87	0.84	0.85	0.012	0.02	0.06	0.50	1.00	0.68
day 88 to 109	1.07	0.98	1.00	1.00	1.00	1.01	0.021	0.35	0.10	0.65	0.04	0.28
Overall	0.84	0.77	0.80	0.83	0.80	0.81	0.009	0.08	0.01	0.51	0.03	0.66
Average daily feed intake, kg												
day 0 to 56	1.83	1.47	1.64	1.69	1.43	1.52	0.032	0.01	0.01	0.33	0.10	0.73
day 56 to 88	2.64	2.30	2.44	2.37	2.17	2.24	0.039	0.01	0.01	0.37	0.11	0.99
day 88 to 109	3.02	2.67	2.77	2.60	2.44	2.56	0.044	0.01	0.01	0.63	0.03	0.13
Overall	2.26	1.93	2.06	2.03	1.82	1.91	0.031	0.01	0.01	0.41	0.05	0.76
Gain:feed ratio												
day 0 to 56	0.41	0.43	0.42	0.45	0.48	0.46	0.006	0.01	0.01	0.56	0.76	0.79
day 56 to 88	0.32	0.35	0.34	0.36	0.38	0.38	0.006	0.01	0.01	0.22	0.12	0.12
day 88 to 109	0.36	0.37	0.36	0.38	0.41	0.39	0.007	0.01	0.02	0.99	0.25	0.99
Overall	0.36	0.39	0.38	0.41	0.43	0.42	0.004	0.01	0.01	0.89	0.90	0.45

[1] A total of 1,032 gilts (24 or 25 pigs per pen and 7 pens per treatment) with an initial average weight of 30.7 kg.

[2]Pigs were sorted based on body weight at placement. HEAVY, pig from the heaviest 50% of the population; LIGHT, pig from the lightest 50% of the population; MIXED, pigs from the whole population with normal distribution around body weight mean.

[3]Mean of combined HEAVY and LIGHT treatment groups.

final BW (119.2 vs. 118.0 kg), CV of individual BW (11.8 vs. 11.0%), or CV of ADG (14.1 vs. 13.3%; Table 3). There was no evidence for difference ($P > 0.42$) among pigs fed diets with or without added fat on back fat, fat-free lean index, percent lean, or loin depth.

For the effects of BW sorting, HEAVY pigs had greater BW compared with LIGHT pigs during each period, but when combined, the average weight of sorted pigs (HEAVY and LIGHT) was similar ($P > 0.40$) to the MIXED pigs. There was a HEAVY vs. LIGHT × fat interaction ($P = 0.05$) for final BW, which occurred because BW was increased when fat was added to diets for LIGHT pigs, but not when fat was added to diets for HEAVY pigs. Pigs sorted into HEAVY pens maintained lower ($P = 0.05$) BW CV compared with that of LIGHT pens throughout the study. Furthermore, sorted pigs had decreased ($P < 0.10$) BW CV throughout the study compared with the MIXED pigs. However, sorting had no effect ($P > 0.38$) on CV of ADG or carcass traits.

Experiment 2

No sort category × fat interaction was observed for any growth responses ($P > 0.26$). Pigs fed diets with added fat had greater ($P < 0.01$) ADG from day 0 to 49 and for the overall experimental period (Table 4). Adding fat to the diets decreased ($P < 0.01$) ADFI but increased ($P < 0.01$) G:F during each period.

Pigs from the HEAVY category had increased ($P < 0.05$) ADG and ADFI, but decreased ($P < 0.01$) G:F, compared with the LIGHT category during each growth period, except for ADG from day 49 to 81 and G:F from day 81 to 95. However, when combining the HEAVY and LIGHT treatment groups, pigs from the SORTED pens had similar ADG, ADFI, and G:F compared with MIXED ($P > 0.25$).

Adding dietary fat increased ($P < 0.01$) BW at the end of each period (Table 5). However, adding fat had no effect ($P > 0.41$) on CV of BW in any period. Feeding pigs diets with fat reduced ($P < 0.01$) CV of ADG from day 49 to 81 (15.3 vs. 12.6%); however, this response was not observed ($P > 0.64$) in other periods.

Pigs from the HEAVY category maintained greater ($P < 0.01$) BW with lower ($P < 0.01$) CV compared with those from the LIGHT category throughout the experiment. There was a HEAVY vs. LIGHT × fat interaction ($P < 0.10$) for BW CV on day 49 and 81. This seemed to be a magnitude effects because in diets without added fat, BW CV was greater in LIGHT pigs than HEAVY, but adding fat to diets had only a modest increase in BW CV among HEAVY and LIGHT pigs. When combining the HEAVY and LIGHT

Table 3. Effects of added fat and initial sort on weight variation, carcass traits in finishing pigs (experiment 1)[1]

Added dietary fat:	0%			6%				Main effect *P*-value			Interaction *P*-value	
Sort category:[2]	HEAVY	LIGHT	MIXED	HEAVY	LIGHT	MIXED	SEM	Fat	HEAVY vs. LIGHT	Sorted[3] vs. MIXED	HEAVY vs. LIGHT by fat	Sorted vs. MIXED by fat
Pig weight, kg												
day 0	34.68	26.79	30.80	34.72	26.79	30.63	0.330	0.88	0.01	0.91	0.95	0.75
day 56	77.62	63.52	70.80	78.38	66.17	71.06	0.930	0.11	0.01	0.55	0.32	0.38
day 88	105.42	89.96	97.41	106.49	93.10	98.60	1.009	0.03	0.01	0.40	0.31	0.60
day 109	125.63	110.90	117.42	124.43	114.08	119.19	1.079	0.17	0.01	0.63	0.05	0.68
Pig weight, CV[4]												
day 0	8.72	11.02	15.87	8.72	12.67	15.42	0.706	0.49	0.01	0.01	0.25	0.30
day 56	11.55	15.69	15.05	12.76	14.72	16.20	1.257	0.65	0.02	0.08	0.39	0.64
day 88	9.07	13.34	13.25	11.38	12.77	14.08	0.997	0.30	0.01	0.02	0.16	0.98
day 109	8.38	12.18	12.40	9.98	12.79	12.59	0.933	0.30	0.01	0.05	0.60	0.58
Average daily gain, CV												
day 0 to 56	18.61	23.68	20.09	19.75	20.35	21.23	2.184	0.85	0.44	0.97	0.31	0.56
day 56 to 88	14.52	14.41	17.35	15.21	17.11	17.33	1.312	0.30	0.18	0.08	0.45	0.45
day 88 to 109	19.06	17.74	22.47	18.99	21.75	18.60	2.526	0.99	0.84	0.60	0.42	0.19
Overall	10.83	14.54	14.48	12.89	15.18	14.14	1.236	0.44	0.05	0.38	0.57	0.43
Carcass traits[5]												
Back fat, mm	14.99	14.15	14.44	15.02	14.41	14.59	0.013	0.59	0.10	0.66	0.75	1.00
Fat-free lean index, %	51.63	51.30	51.53	51.53	51.35	51.58	0.153	0.98	0.20	0.46	0.63	0.80
Lean, %	56.95	57.56	57.14	57.02	57.16	57.48	0.290	0.99	0.38	0.58	0.43	0.32
Loin depth, cm	6.02	6.11	5.90	6.11	5.91	6.27	0.134	0.42	0.85	0.70	0.30	0.07

[1]A total of 1,032 gilts (24 or 25 pigs per pen and 7 pens per treatment) with an initial average weight of 30.7 kg.

[2]Pigs were sorted based on body weight at placement. HEAVY, pig from the heaviest 50% of the population; LIGHT, pig from the lightest 50% of the population; MIXED, pigs from the whole population with normal distribution around body weight mean.

[3]Mean of combined HEAVY and LIGHT treatment groups.

[4]Coefficient of variation.

[5]Values derived from processing plant.

treatment groups, sorted pigs had similar BW, but decreased ($P < 0.01$) CV of BW, compared with MIXED pigs throughout the study. A HEAVY vs. LIGHT × fat interaction ($P = 0.03$) was observed for CV of ADG from day 0 to 49. This response occurred because CV of ADG increased when fat fed to HEAVY pigs, while adding fat to diets for LIGHT pigs decreased CV of ADG. The influence of sorting on CV of ADG was inconsistent with a response observed from day 0 to 49 and day 81 to 95 ($P < 0.05$), but not from day 49 to 81 or the overall trial.

DISCUSSION

Lightweight pigs are a costly problem in all-in, all-out swine production. Variation in growth is costly because it increases the penalty for sort loss, increases the number of days to bring lightweight pigs to market weights, and results in extra facility cost (van Barneveld and Hewitt, 2016; López-Vergé et al., 2018). Variation in growth is the result of differences in health, genetic makeup, and social interactions. Days to market for a group of pigs is dictated by the growth rate of the lightest 50% of the pigs in the barn because they must reach a minimum weight to reduce sort discount by the processor. Thus, within a population of pigs, increasing the ADG has more value in lightweight pigs than their heavy weight counter parts.

Energy is important because it is the most expensive component of the diet, and it has a significant impact on animal performance and nutrient utilization. Increasing dietary energy, such as with addition of dietary fat, is one of the few nutritional tools available to increase ADG for pigs fed an otherwise nutritionally adequate diet. In commercial swine production, dietary energy level often limits ADG (De la Llata et al., 2001b). Many studies have shown that the addition of dietary fat to corn-soybean meal-based diets increases ADG and G:F (Benz et al., 2011; Kellner et al., 2014;

Table 4. Effects of added fat and initial sort on growth performance of finishing pigs (experiment 2)[1]

Added dietary fat:	0%			6%			Main effect *P*-value				Interaction *P*-value	
Sort category:[2]	HEAVY	LIGHT	MIXED	HEAVY	LIGHT	MIXED	SEM	Fat	HEAVY vs. LIGHT	Sorted[3] vs. MIXED	HEAVY vs. LIGHT by fat	Sorted vs. MIXED by fat
Average daily gain, kg												
day 0 to 49	0.83	0.79	0.81	0.86	0.83	0.85	0.010	0.01	0.01	0.89	0.40	0.81
day 49 to 81	0.94	0.93	0.93	0.95	0.96	0.95	0.058	0.16	0.96	0.80	0.77	0.83
day 81 to 95	1.02	0. 90	0.95	1.05	0.93	0.97	0.045	0.43	0.04	0.75	0.99	0.88
Overall	0.88	0.85	0.87	0.91	0.89	0.90	0.008	0.01	0.02	0.91	0.37	0.89
Average daily feed intake, kg												
day 0 to 49	2.12	1.93	2.03	1.98	1.80	1.90	0.025	0.01	0.01	0.83	0.84	0.99
day 49 to 81	2.64	2.49	2.57	2.45	2.28	2.36	0.032	0.01	0.01	0.94	0.82	0.84
day 81 to 95	3.07	2.83	2.99	2.89	2.57	2.68	0.048	0.01	0.01	0.99	0.40	0.26
Overall	2.70	2.28	2.46	2.51	2.09	2.27	0.025	0.01	0.01	0.25	0.91	0.97
Gain:feed ratio												
day 0 to 49	0.39	0.41	0.40	0.43	0.46	0.45	0.005	0.01	0.01	0.93	0.30	0.67
day 49 to 81	0.35	0.37	0.36	0.39	0.42	0.41	0.009	0.01	0.01	0.78	0.75	0.52
day 81 to 95	0.33	0.32	0.32	0.36	0.36	0.36	0.012	0.01	0.86	0.75	0.67	0.86
Overall	0.36	0.38	0.37	0.41	0.43	0.42	0.004	0.01	0.01	0.68	0.28	0.83

[1]A total of 1,176 gilts (28 pigs per pen and 7 pens per treatment) with an initial average weight of 35.1 kg.

[2]Pigs were sorted based on body weight at placement. HEAVY, pig from the heaviest 50% of the population; LIGHT, pig from the lightest 50% of the population; MIXED, pigs from the whole population with normal distribution around body weight mean.

[3]Mean of combined HEAVY and LIGHT treatment groups.

Table 5. Effects of added fat and initial sort on weight variation, carcass traits in finishing pigs (experiment 2)[1]

Added dietary fat:	0%			6%			Main effect *P*-value				Interaction *P*-value	
Sort category:[2]	HEAVY	LIGHT	MIXED	HEAVY	LIGHT	MIXED	SEM	Fat	HEAVY vs. LIGHT	Sorted[3] vs. MIXED	HEAVY vs. LIGHT by fat	Sorted vs. MIXED by fat
Pig weight, kg												
day 0	37.75	32.52	35.28	37.62	32.56	35.09	0.543	0.83	0.01	0.87	0.87	0.88
day 49	78.30	71.09	74.80	79.63	73.33	76.60	0.722	0.01	0.01	0.86	0.53	0.99
day 81	108.30	100.93	104.64	110.04	104.00	107.00	0.752	0.01	0.01	1.00	0.38	0.97
day 95	121.24	113.58	117.49	123.04	117.00	119.89	0.876	0.01	0.01	0.97	0.36	0.89
Pig weight, CV[4]												
day 0	9.33	12.56	15.85	9.99	12.08	15.88	0.751	0.91	0.01	0.01	0.46	0.96
day 49	8.18	11.87	13.12	9.30	10.37	12.92	0.691	0.73	0.01	0.01	0.06	1.00
day 81	8.02	10.39	11.05	8.69	8.69	10.95	0.551	0.41	0.01	0.01	0.04	0.66
day 95	7.23	9.78	9.78	7.47	8.67	9.65	0.479	0.41	0.01	0.01	0.17	0.71
Average daily gain, CV												
day 0 to 49	10.68	15.00	14.78	13.03	12.58	14.36	1.028	0.84	0.04	0.06	0.03	0.83
day 49 to 81	15.61	15.80	14.55	14.21	10.82	12.69	1.134	0.01	0.33	0.62	0.12	0.50
day 81 to 95	18.92	27.30	18.69	19.23	23.07	21.02	1.766	0.72	0.01	0.15	0.21	0.17
Overall	8.86	10.64	9.79	9.44	9.41	9.74	0.612	0.64	0.34	0.74	0.15	0.80

[1]A total of 1,176 gilts (28 pigs per pen and 7 pens per treatment) with an initial average weight of 35.1 kg.

[2]Pigs were sorted based on body weight at placement. HEAVY, pig from the heaviest 50% of the population; LIGHT, pig from the lightest 50% of the population; MIXED, pigs from the whole population with normal distribution around body weight mean.

[3]Mean of combined HEAVY and LIGHT treatment groups.

[4]Coefficient of variation.

Stephenson et al., 2016). In general, for every 1% added dietary fat in a corn-soybean meal based diet, ADG is expected to increase 1% and G:F is expected to improve approximately 2% (De la Llata et al., 2001b), although the improvements can be greater. Benz et al. (2011) observed a 9% improvement in ADG (0.97 vs. 0.89 kg) for pigs fed 5% added fat and Kellner et al. (2014) evaluated

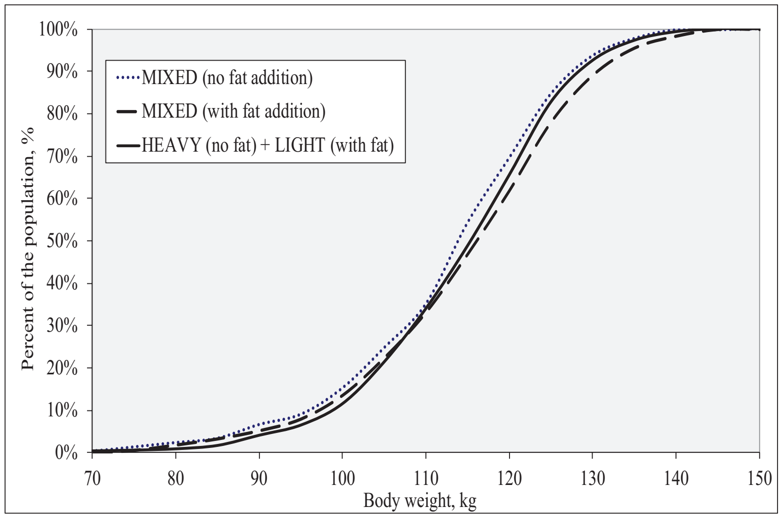

Figure 1. Cumulative sum graph showing percentage of population over BW range. Pigs were sorted based on BW at placement. HEAVY, pig from the heaviest 50% of the population; LIGHT, pig from the lightest 50% of the population; MIXED, pigs from the whole population with normal distribution around BW mean. The graph represents three scenarios: 1) no added fat fed to MIXED pigs, 2) added fat fed to MIXED pigs, or 3) added fat fed to LIGHT pigs but not for HEAVY pigs.

the addition of 6% of different fat sources and found up to 20% greater ADG (1.12 vs. 0.93 kg/d). However, the environment and housing (individual vs. pen) must be considered when comparing results. Patience (2001) calculated that, reducing energy intake by 1% resulted in a decrease in growth rate of about 1.2%. They also calculated that for each 1% reduction in energy intake, market weights would be lowered by approximately 1 kg. In our studies, adding 6% fat in diets for LIGHT pigs increased ADG by 3.9% in experiment 1. In contrast, HEAVY pigs had a slight decrease in ADG (0.83 vs. 0.84 kg/d) when fed diets with added fat. This was unexpected and prompted us to conduct the second study. In experiment 2, adding fat in the diets increased ADG by 3.4% for HEAVY and 4.7% for LIGHT pigs. Regardless, the magnitude of the response for increasing ADG by adding fat was greater for LIGHT pigs than HEAVY pigs in both experiments.

The increase in weight in light pigs from adding dietary fat moved a larger number of lightweight pigs closer and into the packers marketing window. For pigs heavier than the population mean, providing additional energy will increase market weight and move a larger portion of pigs out of the optimal weight range for the packer and increase sort discounts. A secondary analysis of our data was performed to evaluate the implications of feeding the lightest 50% of the population diets with added fat while feeding diets without added fat to the heaviest 50% of the population. This population (combined) was then compared with the unsorted mixed populations that were fed diets either with or without added fat. Using individual weights from these treatments in both studies, a cumulative sum graph was created (Figure 1) to represent the portion of the population that would be at or below a specific weight. As the graph illustrates, adding fat to the diet for the mixed population simply shifts the population to the right resulting in fewer pigs being lower than the desired weight range for the packer. Unfortunately, this shift of the curve for the mixed population also results in more pigs being heavier than the optimal weight range for the packer when fat is added to the diet. If pigs would be sorted at the beginning of the finisher with the lightest 50% of pigs fed higher energy diets and the heaviest 50% of pigs fed lower energy diets, dietary fat could be fed to only the lightweight population that needed the extra weight gain. This situation is simulated in the combined group in Figure 1. Using this approach, the lower end of the curve is shifted to the right because adding dietary fat increased ADG for the lightweight pigs. The upper end of the curve is not shifted to the right because the heavy pigs would be fed the lower energy diet without added fat. This illustrates that an initial sorting in conjunction with feeding two different dietary energy treatments may be effective in moving a higher percentage of the pigs into the packer's ideal marketing grid. In addition, it is important to note that the economics of adding fat to finishing diets depend on the design of the production system as well as the prices of corn, soybean meal, fat, and carcass price. For instance, the value of the additional weight will depend on the availability of finishing space. If extra space already exists, the increase in ADG is worth only fewer days in the facility. When space is limited, increasing the ADG is worth the extra weight sold at market (De la Llata et al., 2001a).

Many producers try to minimize variation and discounts by sorting pigs into more uniform weight groups at placement into the finishing barn. Several studies (Brumm et al. 2002; Wolter et al., 2002; Cámara et al., 2016) have reported that sorting pigs into uniform weight pens did not improve overall performance. The present study was designed to simulate the field scenarios where feeder pigs were sorted into two weight categories (HEAVY vs. LIGHT). In addition to the comparison between HEAVY vs. LIGHT categories, contrasts were also performed to compare the combination of HEAVY and LIGHT treatment groups (referred as “sorted”) to MIXED (unsorted) pigs. This was done to determine whether the sorting practice improved pig performance. Results from both experiments suggested that even though heavier pigs maintained greater ADG than lighter pigs, the combination of sorted pigs had the same ADG, ADFI, and G:F as that of unsorted pigs. In experiment 2, there was an inconsistent response of sorting on CV of ADG. This effect of sorting was not observed in experiment 1. Magowan et al. (2011) found lower BW CV at 10 and 15 wk of age for pigs in uniform weight groups compared to mixed weight groups. Conversely, O’Connell et al. (2005) determined that the formation of uniform groups at 4 wk of age did not affect 21 wk of age BW CV. Brumm and Miller (1996) also found an inconsistent influence of added dietary fat on CV of final weight with added fat having no influence on CV in one experiment, but increasing CV in the second experiment. Sorting pigs at or near time of marketing can reduce sort discounts received from packers; however, the remained pigs in the facility assume greater facility cost and reduce profitability. Thus, it is critical to increase ADG of lightweight pigs in conjunction with sorting.

In summary, because adding fat to the diets of lightweight pigs improved ADG in both experiments, dietary fat could be used selectively in the barn to increase the weight of the lightest 50% of the pigs. Moreover, feeding additional dietary fat did not affect the variation in BW or ADG. By increasing dietary fat fed to the light pigs and removing fat from diets of heavy pigs, producers may be able to increase the percentage of pigs marketed within the packers’ ideal grid. These studies also show that sorting feeder pigs based on initial BW when placing into finishers did not improve growth performance. Sorting decreased BW variation, but not ADG variation, within a population.

Conflict of interest statement. None declared.

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