The Effects of Soybean Hulls and Their Particle Size on Growth Performance and Carcass Characteristics of Finishing Pigs[1]

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Summary

A total of 1,235 pigs (PIC 337 × 1050; initially 68.4 lb) were used in a 118-d study to determine the effects of 7.5 and 15% ground or unground soybean hulls on growth performance and carcass characteristics of finishing pigs raised in a commercial environment. Pens of pigs were balanced by initial weight and randomly allotted to 1 of 5 dietary treatments in a completely randomized design with 26 to 28 pigs per pen and 9 replications per treatment. Treatments were arranged in a 2 × 2 factorial, and main effects were soybean hull particle size (unground or ground, 787 and 370 µ, respectively) and amount of soybean hulls (7.5 or 15%) in corn-soybean meal–based diets. The fifth treatment was a positive control, a corn-soybean meal–based diet. No particle size × soybean hull interactions ($P > 0.18$) occurred. Overall (d 0 to 118), increasing soybean hulls, regardless of particle size, did not affect ADG but numerically increased ($P = 0.11$) ADFI, resulting in poorer (linear, $P < 0.02$) F/G. Although F/G became worse, increasing soybean hulls in the diet improved (linear, $P < 0.002$) caloric efficiency on an ME and NE basis, indicating that published energy values undervalue the energy content of soybean hulls. Unexpectedly, grinding soybean hulls to a lower particle size worsened F/G ($P < 0.04$) and caloric efficiencies ($P < 0.03$).

Because adding soybean hulls increases the dietary fiber content, pigs fed high amounts of soybean hulls would be expected to have greater gut fill, which is reflected by the lower (linear, $P < 0.03$) carcass yield and HCW for pigs fed increasing amounts of soybean hulls. Increasing soybean hulls decreased (linear, $P < 0.0006$) backfat depth. The reduction in backfat resulted in an increase ($P < 0.008$) in percentage lean and fat-free lean index (FFLI) with increasing soybean hulls. Grinding soybean hulls to a finer particle size prior to diet manufacturing increased backfat depth ($P < 0.002$) and decreased ($P < 0.004$) percent lean and FFLI.

In summary, increasing amounts of dietary soybean hulls to 7.5 or 15% did not affect ADG, ADFI, or final BW in growing and finishing pigs; however, F/G became poorer and carcass yield and HCW decreased. Thus, producers using soybean hulls in finishing diets may want to withdraw or reduce levels prior to market to decrease the negative impact on carcass yield. Further processing soybean hulls by grinding to a finer particle size provided no advantages in performance and actually worsened F/G.

Key words: finishing pig, particle size, soybean hulls

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Introduction

Soybean hulls are a readily available co-product resulting from the cracking and dehulling process in soybean oil extraction, but they may be underutilized in many swine diets because of their low energy value (corn NE = 1,202 kcal/lb; soybean hulls NE = 455 kcal/lb; INRA 2004[3]) and the lack of published data. Research at Purdue University (Bowers et al., 2000[4]) has shown that low amounts of soybean hulls (3%) improved finishing pig ADG, ADFI, and carcass characteristics, but higher amounts of soybean hulls reduced growth performance and worsened F/G.

Reducing particle size of cereal grains is well known to improve feed efficiency. In a recent study, Moreira et al. (2009[5]) found that grinding soybean hulls increased ME for finishing pigs when soybean hulls were ground from 751 μ to 430 μ, with potential improvements in growth performance. Validation of the benefits of grinding soybean hulls on growth performance is needed; therefore, the objectives of this study were to evaluate the effects of: (1) increasing amounts of soybean hulls (0, 7.5, and 15%), and (2) soybean hull particle size (787 vs. 370 μ) on the growth performance of growing and finishing pigs in a commercial setting.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment.

The study was conducted at the commercial research-finishing barn in southwestern Minnesota. The barns were naturally ventilated and double-curtain-sided. Pens had completely slatted flooring and deep pits for manure storage. Each pen was equipped with a 5-hole stainless steel dry self-feeder and a cup waterer for ad libitum access to feed and water. Daily feed additions to each pen were accomplished through a robotic feeding system (FeedPro; Feedlogic Corp., Willmar, MN) capable of providing and measuring feed amounts for individual pens.

A total of 1,235 pigs (PIC 1050 × 337) with an initial BW of 68.4 lb were used in a 118-d study. A similar number of barrows and gilts were placed in each pen, with 26 to 28 pigs per pen and 9 pens per treatment. Pens of pigs were allotted to 1 of 5 dietary treatments in a completely randomized design while balancing for BW. Treatments were arranged as a 2 × 2 + 1 factorial with main effects of soybean hull (unground or ground, 787 and 370 μ, respectively) and soybean hull inclusion (7.5 or 15%). The fifth treatment was a positive control, a corn-soybean meal–based diet without soybean hulls.

All soybean hulls were sourced from the same location (South Dakota Soybean Processors, Volga, SD). Each lot of soybean hulls was split into equal portions, and half was transported to the South Dakota State University Feed Mill (Brookings, SD) then

[3] INRA (Institut National de la Recherche Agronomique). 2004. Tables of composition and nutritional value of feed materials, Sauvant, D., J-M. Perez and G. Tran, Eds. Wageningen Academic Publishers, The Netherlands and INRA, Paris, France.

[4] Bowers et al., Purdue University Swine Day 2000, pp. 39–42.

[5] Moreira, I., M. Kutschenko, D. Paiano, C. Scapinelo, A. E. Murakami, and A. R. Bonet de Quadros. 2009. Effects of different grinding levels (particle size) of soybean hull on starting pigs performance and digestibility. Braz. Arch. Biol. Technol. v.52 n.5:1243–1252.

ground through a 1/16-in. screen. After grinding, hulls were transported along with the unground soybean hulls to the New Horizon Farm's feed mill (Pipestone, MN) for diet manufacturing. All diets were fed in meal form and treatments were fed in 4 phases, from 70 to 120 lb, 120 to 170 lb, 170 to 240 lb, and 240 lb to market. Diets in the last phase also contained 9 g/ton of Ractopamine HCl (Paylean; Elanco Animal Health, Greenfield, IN).

Pens of pigs were weighed and feed disappearance was recorded at d 14, 28, 42, 53, 66, 82, 94, and 118 to determine ADG, ADFI, and F/G. On d 94 of the experiment, the 4 heaviest pigs (2 barrows and 2 gilts, determined visually) per pen were weighed and sold according to the farm's normal marketing procedure. At the end of the trial (d 118), pigs were individually tattooed by pen number to allow for carcass data collection. Pigs were transported to JBS Swift and Company (Worthington, MN) for processing and carcass data collection. Hot carcass weights were measured immediately after evisceration and standard carcass criteria of percentage yield, HCW, percentage lean, backfat depth, and loin depth were collected. Percentage carcass yield was calculated by dividing live weight at the plant with carcass weight at the plant as reported by the processor. The experimental data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Pen was the experimental unit for all data. Interactions between particle size and dietary soybean hull levels were analyzed, as well as the main effects of particle size and the linear and quadratic effects of increasing soybean hulls, regardless of particle size. Analysis of backfat depth, loin depth, and percentage lean were adjusted to a common carcass weight using HCW as a covariate. Results were considered significant at $P \leq 0.05$ and considered a trend at $P \leq 0.10$.

Results and Discussion

The analyzed nutrient levels of the soybean hulls used in the experiment were similar to those used in diet formulation (Table 1). In addition, reducing the particle size of soybean hulls improved bulk density compare to the unground soybean hulls. Adding increasing amounts of soybean hulls to the diets increased crude fiber (CF; from 2.6 to 7.2%) and NDF (from 9.2 to 16.3).

Despite these increases in dietary CF and NDF (Table 2) with added soybean hulls, no negative effects were observed on ADG, ADFI, or final live BW (Table 3); however, increasing dietary soybean hulls decreased ME and NE energy of the diet and resulted in the worsening of F/G ($P < 0.02$). Caloric efficiency improved ($P < 0.002$) on an ME and NE basis as soybean hulls were added, indicating that the energy values of soybean hulls were underestimated in diet formulation. Unexpectedly, grinding the soybean hulls did not influence ADG or ADFI, but the numerical changes in these criteria resulted in poorer ($P < 0.04$) F/G and caloric efficiency on an ME and NE basis.

For carcass characteristics, increasing soybean hulls, regardless of soybean hull particle size, reduced (linear, $P < 0.03$) carcass yield and HCW. Backfat depth also was reduced (linear, $P < 0.0006$) when soybean hulls were added to the diet. Because of the reduction in backfat depth, percent lean and FFLI increased (linear, $P < 0.003$) as soybean hull level increased in the diet. Reducing the particle size of soybean hulls reduced ($P < 0.002$) backfat depth, resulting in an increase ($P < 0.004$) in percentage lean and FFLI.

In summary, based on data from this study, soybean hulls can be used in finishing pig diets up to 15% without negative effects on ADG, ADFI, or live pig weights; as expected, feed efficiency worsens with the addition of soybean hulls due to a decrease in dietary energy, but the improvement in caloric efficiency indicates that the energy value of soybean hulls is underestimated by published values when used at lower levels in the diet. Soybean hulls increase dietary CF and NDF, which can lead to greater gut fill and an increase in digestive tract tissue weights, thus causing a reduction in carcass yield and HCW. The worsening of feed efficiency for pigs fed soybean hulls with reduced particle size was unexpected, and why this occurred is unclear. These data suggest that soybean hulls do not respond similarly to cereal grains when fed at a reduced particle size in growing and finishing pig diets.

Table 1. Chemical analysis of soybean hulls (as-fed basis)[1]

Item	Percentage	
DM	91.51	
CP	10.61 (9.80)[2]	
ADF	43.6	
NDF	55.9	
Crude Fiber	36.3 (33.3)	
Ca	0.58 (0.54)	
P	0.11 (0.11)	
	Ground	Unground
Bulk density, lb/bu	41.26	36.34
Particle size, µ	370	787

[1] Samples of every batch of soybean hulls used were analyzed and averages are reported.
[2] Values in parentheses indicate those used in diet formulation.

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

	Phase 1			Phase 2			Phase 3			Phase 4		
Item Soybean hulls, %:[2]	0	7.5	15	0	7.5	15	0	7.5	15	0	7.5	15
Ingredient												
Corn	73.09	66.09	58.98	78.78	71.61	64.63	83.01	75.84	64.63	75.24	68.03	60.94
Soybean meal, 46.5% CP	24.44	24.02	23.71	18.96	18.75	18.33	14.89	14.67	18.33	22.62	22.41	22.09
Soybean hulls	-	7.50	15.00	-	7.50	15.00	-	7.50	15.00	-	7.50	15.00
Monocalcium P, 21% P	0.62	0.63	0.65	0.51	0.50	0.48	0.40	0.40	0.40	0.25	0.28	0.28
Limestone	0.95	0.85	0.75	0.95	0.85	0.75	0.93	0.83	0.73	0.90	0.80	0.70
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
DL-methionine	0.03	0.045	0.06	-	0.015	0.030	-	0.005	0.010	0.050	0.060	0.075
L-threonine	0.045	0.05	0.0525	0.015	0.019	0.030	0.03	0.035	0.040	0.070	0.075	0.080
Biolys[3]	0.370	0.360	0.345	0.325	0.305	0.295	0.030	0.035	0.040	0.008	0.008	0.008
Phytase[4]	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.000	0.008
Paylean, 9 g/lb	-	-	-	-	-	-	-	-	-	0.05	0.05	0.05
Total	100	100	100	100	100	100	100	100	100	100	100	100

continued

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

	Phase 1			Phase 2			Phase 3			Phase 4		
Item Soybean hulls, %:[2]	0	7.5	15	0	7.5	15	0	7.5	15	0	7.5	15
Calculated analysis												
Standardized ileal digestible (SID) amino acids,%												
Lysine	1.00	1.00	1.00	0.84	0.84	0.84	0.72	0.72	0.72	0.95	0.95	0.95
Isoleucine:lysine	65	64	64	66	66	66	68	68	67	65	65	65
Leucine:lysine	146	143	140	159	156	152	173	168	164	150	147	143
Methionine:lysine	29	30	31	28	29	30	30	30	30	32	32	33
Met & Cys:lysine	57	57	57	58	58	58	63	61	60	60	60	60
Threonine:lysine	61	61	61	61	61	61	65	65	65	65	65	65
Tryptophan:lysine	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Valine:lysine	74	73	72	77	76	75	81	79	78	75	74	73
Total lysine, %	1.12	1.13	1.14	0.94	0.96	0.97	0.81	0.83	0.84	1.06	1.08	1.09
ME, kcal/lb	1,517	1,450	1,382	1,519	1,452	1,385	1,522	1,455	1,387	1,523	1,455	1,388
SID lysine:ME, g/Mcal	2.99	3.13	3.28	2.51	2.62	2.75	2.15	2.25	2.35	2.83	2.96	3.10
CP, %	17.9	17.9	17.8	15.8	15.8	15.7	14.2	14.2	14.2	17.3	17.3	17.3
Crude fiber, %	2.6	4.9	7.2	2.5	4.8	7.1	2.4	4.7	7.1	2.5	4.9	7.2
ADF[5]	3.4	6.2	9.0	3.2	6.1	8.9	3.1	6.0	8.8	3.3	6.2	9.0
NDF[5]	9.2	12.7	16.2	9.3	12.8	16.3	9.3	12.8	16.3	9.2	12.8	16.3
Ca, %	0.58	0.58	0.58	0.54	0.54	0.54	0.50	0.50	0.50	0.49	0.49	0.49
P, %	0.50	0.49	0.48	0.46	0.44	0.42	0.42	0.41	0.39	0.42	0.41	0.40
Available P, %	0.29	0.29	0.29	0.25	0.25	0.25	0.23	0.23	0.23	0.21	0.21	0.21

[1] Phase 1 diets fed from d 0 to 14, Phase 2 from d 14 to 53, Phase 3 from d 53 to 94, and Phase 4 from d 94 to 118.
[2] In diets containing soybean hulls, the soybean hulls were either unground at 787 µ or ground to 370 µ.
[3] Lysine source (Evonik Inc., Kennesaw, GA).
[4] Optiphos 2000 (Enzyva LLC, Sheridan, IN), providing 170.25 phytase units (FTU)/lb, with a release of 0.10% available P.
[5] Soybean hulls ADF and NDF values are from INRA (Institut National de la Recherche Agronomique), 2004. All other values taken from NRC, 1998.

Table 3. Effects of ground and unground soy hulls on growth performance and carcass characteristics[1]

							Probability, P<			
Soybean hulls, %:	0	7.5		15			Soybean hull	Soybean hulls	Soybean hulls	
Item Particle size:	-	Ground	Unground	Ground	Unground	SEM[2]	particle size	level	Linear	Quadratic
d 0 to 118										
ADG, lb	1.84	1.85	1.85	1.81	1.86	0.022	0.34	0.45	0.78	0.53
ADFI, lb	4.69	4.86	4.73	4.79	4.80	0.054	0.31	0.96	0.11	0.31
F/G	2.56	2.63	2.58	2.67	2.60	0.026	0.04	0.26	0.02	0.75
Caloric efficency[3]										
ME	3,874	3,853	3,772	3,760	3,664	39.2	0.03	0.01	0.002	0.60
NE	2,869	2,810	2,752	2,700	2,632	28.6	0.03	0.0002	0.0001	0.61
BW, lb										
d 0	68.3	68.4	68.3	68.4	68.4	1.75	0.99	0.97	0.96	0.99
d 118	282.2	283.5	280.9	278.2	283.6	3.06	0.64	0.68	0.73	0.83
Carcass characteristics										
Plant carcass yield, %	76.26	75.23	75.42	75.16	74.96	0.361	0.55	0.12	0.001	0.13
HCW	208.3	206.9	204.4	201.9	202.1	2.32	0.62	0.13	0.03	0.83
Backfat depth, in.	0.61	0.59	0.56	0.58	0.54	0.010	0.002	0.13	0.0006	0.38
Loin depth, in.	2.62	2.56	2.60	2.61	2.57	0.026	0.84	0.67	0.32	0.25
Lean, %	57.44	57.54	58.06	57.82	58.39	0.186	0.004	0.12	0.008	0.89
FFLI[4]	54.12	54.28	54.75	54.50	55.07	0.168	0.003	0.13	0.003	0.63

[1] A total of 1,235 pigs (PIC 337 x 1050; initially 68.4 lb) were used in a 118-d study with 9 replications per treatment.
[2] No soybean hull particle size × soybean hull level interactions P > 0.18.
[3] Caloric efficiency is expressed as kcal/lb gain.
[4] Fat-free lean index was calculated using NPPC (2000) guidelines for carcasses measured with the Fat-O-Meater such that FFLI = ((15.31 + HCW, lb) – (31.277 × last-rib fat thickness, in.) + (3.813 × loin muscle depth, in))/HCW, lb.