Low-quality soybeans and corn as feedstuffs for swine

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Summary: *In this paper, we review the efficacy of feeding low-test-weight corn and green soybeans to pigs. With the wet spring and early frost in 1995, there could be an increased amount of low-test-weight corn and green soybeans. However, with proper handling, immature green soybeans and low-test-weight corn can be successfully and economically incorporated into swine diets without a significant drop in pig performance.*

Due to delayed planting, a slow growing season, and an early frost, a large portion of the 1992 and 1993 United States soybean and corn crop was of poor quality in the upper midwest. A high percentage of the corn had a low test weight and soybeans were often green and immature. In addition, there were several reports of molds and mycotoxins in the corn. This scenario is not uncommon and often farmers must decide whether to sell their grain at discounted prices or market it through their livestock. In fact, due to the wet spring and early frost experienced in most of the midwest in 1995, there is the potential for a great deal of low-test-weight corn and green soybeans. In this paper, will review feeding low-quality corn and soybeans to swine and discuss the expected performance from using these feedstuffs.

Immature soybeans

Soybeans are purchased to make soy oil with soybean meal sold as a byproduct. Since soybean meal is a byproduct, farmers most often find it more profitable to sell their soybeans and buy back soybean meal to feed to their pigs.[1] When the soybean plant is frost-damaged prior to reaching full maturity, the soybeans are immature and are usually very green due to a high chlorophyll content. Because the chlorophyll stays with the soy oil when extracted, expellers won't buy green soybeans because there is no market for green soy oil. Chlorophyll levels will decrease with time, but most producers don't have enough bin space to store their soybeans for an extended period of time. Therefore, producers must either sell their beans at a large discount or market them through pigs.

Depending on stage of maturity, frost-damaged soybeans have the same nutritive content as mature soybeans.[2] Therefore, the farmer can either feed the immature soybeans raw or have them heat-treated by extrusion, cooking, or roasting.

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Raw soybeans

Raw soybeans contain anti-growth factors that retard growth and performance in most classes of swine. These factors include trypsin inhibitors, urease, and lipoxidase. Danielson[3] reported that young growing pigs fed uncooked soybeans exhibited poorer gains and efficiency because the beans inhibited the ability of trypsin to break down the protein into individual amino acids during digestion. Consequently, he recommended that raw soybeans be fed only to sows and replacement gilts. Other researchers have observed that raw soybeans could effectively replace all the soybean meal in sow diets.[4–6] Other researchers[7,8] reported that raw soybeans could be successfully used as the supplemental protein source in both gestation and lactation diets without affecting sow or litter performance. The researchers described improved pig survival rate in newborns when raw soybeans were fed to sows in the gestation and lactation diets, most probably due to the increased fat levels from raw soybeans. Currently, most swine nutritionists recommend feeding raw soybeans only to gestating sows and gilts and keeping them out of lactation diets because the poor palatability of the raw soybeans can lower feed intake.

The protein quality of raw soybeans (full fat) is dependent upon its amino acid profile. Methionine is the only essential amino acid considered to be marginal in raw soybeans. Full-fat soybeans are approximately 38% protein, 2.25% lysine, and 18% fat. This high level of fat is a convenient way to incorporate fat into swine diets. Fat reduces the dustiness and increases the energy density of the diet. In typical swine diets formulated with raw soybeans, an additional 3%–4% fat is contributed by the soybeans.[4]

When gestating sows are fed raw soybeans, the beans need to be ground with a hammer mill or rolled by a roller mill before being blended with the grain to ensure proper mixing and uniform intake by the sow. The oil content of the raw soybeans, environmental temperatures, and humidity dictate the particle size that works best. When processed too finely, the raw soybean oil may cause lodging and bridging in feeders and bulk bins, as well as other handling difficulties. If ground soybeans or a complete mixed diet containing raw soybeans are to be stored for any length of time (especially during warm weather), an antioxidant should be added to prevent rancidity, which could reduce palatability and fat-soluble vitamin content. If possible, raw soybeans should be processed just prior to blending with other ingredients in order to maintain adequate diet quality. Raw soybeans should be dried and stored at a moisture not to exceed 12%. Long-term storage should be avoided because of the possibility of oxidative rancidity.[4]

To date, there are no published studies on feeding raw, immature

Table 1

Effect of immature soybeans on grow-finish pig performance (40–230 lb)[a]

			Corn-extruded soybeans[c]			
	C-SBM[b]	C-SBM + oil	100:1	67:33	33:67	1:100
ADG, lb (kg)	1.81 (0.82)	1.77 (0.80)	1.79 (0.81)	1.83 (0.83)	1.77 (0.80)	1.79 (0.81)
ADFI, lb[d] (kg)	5.65 (2.50)	5.24 (2.43)	5.35 (2.43)	5.27 (2.40)	5.12 (2.33)	5.22 (2.37)
Feed/gain[d]	3.13	2.96	2.98	2.87	2.89	2.91

[a] R.C. Thaler (South Dakota State University), 1992 (18 pigs/treatment)

[b] C-SBM = corn-soybean meal.

[c] Mature soybeans:immature soybeans ratio

green soybeans to gestating sows. However, Thaler[2] found immature soybeans to be comparable to mature soybeans in protein (38%), fat (18%), and energy (ME 1623 kcal per lb) content. Therefore, one could theorize that raw, immature soybeans have a feeding value similar to that of mature raw soybeans for sows.

Heat-treated immature soybeans

Immature soybeans can safely be fed to growing swine if properly extruded first. A recent study at South Dakota State University[2] demonstrated that extruded immature soybeans can replace up to 100% of the soybean meal in grower and finisher diets when formulated on a lysine basis without detrimentally affecting growth performance or carcass quality of growing pigs (Table 1). Loin eye areas were 36.7 cm^2 (5.69 in^2) for the control group, 36.6 cm^2 (5.67 in^2) for the soy-oil added treatment, and 35.9 cm^2 (5.56 in^2) for the extruded soybean treatment. Backfat thickness were 26 mm (1.02 in) for the control group, 26 mm (1.02 in) for the soy-oil added treatment, and 27 mm (1.06 in) for extruded soybean treatment. This study also emphasizes the importance of properly extruding green, raw soybeans to inactivate the anti-growth factors in raw soybeans.

The replacement of soybean meal with extruded immature soybeans should not be made on a pound for pound basis in swine diets because green soybeans contain less protein (38% versus 44%) and lysine (2.25% versus 2.90%) than soybean meal. Higher inclusion rates of soybeans are needed to reach the desired protein level. However, the protein and fat content of soybeans can vary greatly (36% to 43% protein and 16% to 20% fat), so it is extremely important to analyze the extruded soybeans prior to formulating rations to ensure properly balanced rations (see Appendix A for proper sampling techniques). To make the switch, diets should be formulated on a lysine basis.[9] When replacing the soybean meal with extruded soybeans, the fat content of the total diet will increase 3%–4%. The increase in fat content of the swine diet will result in a 8%–10% improvement in feed efficiency and a 5%–10% reduction in feed intake. This drop in feed intake requires the density of the other nutrients to be increased by 5%–10% in order to maintain a constant daily intake of all nutrients.[10]

Economic considerations in feeding extruded immature soybeans

To determine the economic feasibility of feeding immature green soybeans, Hawton[9] offered the following guidelines:

The feeding value of one bu of heat-treated, whole soybeans is approximately equal to 22.7 kg (50 lb) of 44% soybean meal plus 11.3 kg (25 lb) of corn. This means that, if the selling price per bu for immature soybeans plus the extrusion/roasting cost per bu is less than the cost of 22.7 kg (50 lb) of soybean meal plus 4.3 kg (25 lb) of corn, the farmer is money ahead feeding the processed immature soybeans.

Example

Assumptions:

- corn = $2.25 per bu ($0.04 per lb)
- soybean meal (44%) = $220 per T ($0.11 per lb)
- it costs $30.00 per ton to extrude immature soybeans
- there is an 8% shrink during the extruding process

It would be economical to feed the extruded soybeans to the growing-finishing hogs if farmers would receive $5.52 per bu or less for their immature soybeans at the elevator (Table 2).

Immature low-test-weight corn

Swine producers with immature low-test-weight corn can sell the corn at discounted prices or feed it to their pigs. Often the question arises, "How much, if any, is performance hurt by feeding low-test-weight corn to my hogs?" Low-test-weight corn tends to be higher in crude protein, fiber, and ash, and lower in fat and starch than normal corn (25. 4 kg [56 lb] per bu).

Initial research[11] indicated that the feeding value of corn dropped 2%–3% for every 2.27-kg (5-lb) decrease in bu weight. As a result, performance reduction was greater for starter, grower, and lactation situations in which pigs are in an energy-dependent phase of growth (Table 3).

Based on the above research, some nutritionists have recommended adding 2%–3% fat, if cost effective, to properly formulated

Table 2

Calculating the economics of feeding extruded, immature soybeans to pigs

Calculated value of:	
50 lb of 44% SBM (50 × 0.11) =	$5.50
25 lb of corn (25 × 0.04) =	$1.00
Total =	$6.50
Cost of extruding soybeans	
before shrink =	$30.00 / T
after 8% shrink (30.00 ÷ (1.00 – 0.08))=	$32.61 / T
cost per lb soybeans (32.61 ÷ 2000)=	$0.0163 / lb
cost per bu soybeans (.0163 × 60)=	$0.978 / bu

Therefore, if the market value of immature soybeans is ≤ $5.52/bu ($6.50 total value of corn plus SBM less $0.98 cost of extruding soybeans), it is economical to extrude the immature beans and feed them to pigs.

Note: This equation takes into consideration only the current diet costs and is not adjusted for the expected 8% to 10% improvement in feed efficiency from the higher fat levels of the extruded immature soybeans.

Feeding value comparison of Corn-SBM to heat-treated soybeans

Analysis of 25 lb corn plus 50 lb SBM:

CP % =	24.2 ÷ 75 =	32.27 %
Lysine % =	1.50 ÷ 75 =	2.00 %
Kcal / lb =	111,250 ÷ 75 =	1483.00 Kcal / lb

Comparison of 75 lb Corn-SBM to 1 bu (60 lb) heat-treated soybeans:

	lb	CP%	(lb CP)	Lys%	(lb Lys)	Kcal / lb	tot Kcal
Corn	25	8.8	2.2	0.24	0.06	1500	37,500
SBM	50	44.0	22.0	2.88	1.44	1475	73,750
Total Corn + SBM	**75**	**32.3**	**24.2**	**2.00**	**1.50**	**1483**	**111,250**
Heat-treated soybeans	**60**	**38.0**	**22.8**	**2.25**	**1.35**	**1610**	**96,600**

Table 3

Light test weight corn for growing-finishing pigs (60–200 lb)[a]

	Light corn (41 lb/bu)	Medium corn (48 lb/bu)	Heavy corn (54 lb/bu)
ADG, lb (kg)	1.66 (0.73)	1.69 (0.77)	1.74 (0.79)
ADFI, lb (kg)	5.89 (2.68)	6.44 (2.93)	6.21 (2.82)
Feed/gain	3.56	3.82	3.56

[a] Holden, P.J., Iowa State University, 1975, Swine Day Report.

growing-finishing rations using low-test-weight corn. Additionally, because of the higher fiber content and slightly lower feeding value of low-test-weight corn, its use for pigs during the starter and lactation phases has not been recommended. The breeding-gestation herd can be fed lightweight corn if it is not contaminated with molds or mycotoxins.[9]

Research in Canada[12] did not find bulk density (test weight) of corn to have a consistent effect on rate of gain or feed:gain ratio in nursery pigs. Another recent feed trial[13] indicated that the performance of young growing pigs (from 3.15–30.8 kg [29–68 lb] bodyweight) was not compromised by the test weight of corn when it was added to the diet on a weight basis (Table 4). Average daily gains, feed intakes, and feed conversions of pigs were similar when fed diets formulated with 9.01-kg (42-lb), 23.1-kg (51-lb), or 21.3-kg (59-lb) per bu corn. Inferior performance was noted with corn weighing 21.3 kg (47 lb) per bushel. However, this corn was found to be contaminated with the mycotoxin deoxynivalenol (vomitoxin), which may have depressed feed intake.

This trial implies that young growing pigs can use mildly lightweight corn without a significant drop in performance, and it may not be necessary to supplement the ration with fat. In addition, this study demonstrated the importance of testing low-test-weight corn for molds and

Table 4

Effect of corn weight on performance of growing-finishing swine (29–68 lb)[a]

	Corn weight (lb / bu)			
	42	47	51	59
ADG, lb (kg)	1.43 (0.65)	1.32 (0.60)	1.41 (0.64)	1.41 (0.64)
ADFI, lb (kg)	2.91 (1.32)	2.69 (1.22)	2.87 (1.30)	2.84 (1.29)
Feed:gain	2.04	2.00	2.04	2.04

[a] Rozeboom DW, et al., 1993, *An Sci Newsletter*

Table 5

Effect of fat additions on feeding value of light–test-weight corn for swine[a]

	Corn (56) SBM	Corn (36) SBM	Corn (36) Extr soy	Corn (36) Soy soll	Corn (44) SBM	Corn (44) Extr soy	Corn (44) Soy oil
Overall (40–240 lb; 18–109 kg)							
Daily gain, lb (kg)	1.81 (0.82)	1.75 (0.80)	1.70 (0.77)	1.74 (0.79)	1.65 (0.75)	1.71 (0.78)	1.77 (0.80)
Daily feed, lb (kg)	5.00 (2.27)^{b}	2.87 (2.67)^{d}	5.06 (2.30)^{b}	5.26 (2.39)^{bc}	5.74 (2.61)^{cd}	5.05 (2.30)^{b}	5.36 (2.41)^{bcd}
Feed:gain	2.77^{b}	3.35^{d}	2.98^{bc}	3.02^{c}	3.48^{d}	2.95^{bc}	3.00^{bc}
Carcass (240lb; 109kg)							
10th rib fan, in (mm)	0.81 (21)^{bc}	0.77 (20)^{c}	0.81 (21)bc	0.82 (21)^{bc}	0.76 (19)^{c}	0.79 (20)^{bc}	0.87 (22)^{b}
Loin eye area, sq in (cm^2)	4.92 (31.7)	4.86 (31.4)	4.80 (31.0)	4.71 (30.4)	4.98 (32.1)	4.89 (31.5)	4.69 (30.3)
Percent lean	50.3^{bc}	50.9^{b}	49.9^{bcd}	49.4^{cd}	51.1^{b}	50.4^{bc}	48.9^{d}

[a] Thaler, R.C., 1995, South Dakota State University (unpublished)

[b, c, d] Means with unlike superscripts differ ($P<.05$)

mycotoxins.

When corn test weight drops below 9.01 kg (42 lb) per bushel, added fat will enhance grower-finisher pig performance.[14] Recent unpublished data from South Dakota State University showed that fat additions of either extruded soybeans or soy oil improved pig performance almost to the level of pigs consuming 27.2 kg (60 lb) per bu corn (Table 5). Therefore, it is essential to get an accurate analysis of both nutrient content and density (test weight) when incorporating lightweight corn into swine diets.

The lack of response of corn test weight on gains is similar to the results observed in a joint SDSU-Kansas State University trial feeding lightweight sorghum.[15] Feeding 16-kg (35-lb) sorghum tended to decrease grower performance, but did not affect finisher performance.

In summary, producers must keep in mind that even though low quality feedstuffs may not result in the best performance, they may lower feed cost per cwt of gain to make the most economical gain. Also, it may be in the best interest of the whole farming operation to suffer slightly poorer performance on the livestock side if it adds more value to the grain side.

Implications

The keys to successfully using low-quality feedstuffs are:

- Test corn and soybeans for lysine, fat, weight, and mycotoxins.
- Only feed raw soybeans in the gestation diet.
- Extruded immature soybeans can be the sole supplemental protein source for grower-finisher pigs.
- Balance all diets on a lysine basis.
- Vitamin and mineral inclusion rates may need to be adjusted to compensate for decreased feed intake associated with increased fat levels provided by raw whole soybeans and processed immature green soybeans in the diet.
- Incorporate low-test-weight corn into swine diets on a weight basis and not volumetric basis.
- Add supplemental fat to grower-finisher diets when the corn test weight is below 18 kg (40 lb) per bushel.

References

1. Shurson J. University of Minnesota, Personal communications.1993.

2. Thaler RC. Feeding value of frost-damaged soybeans for growing-finishing pigs. SD Agr Exp Sta Swine Research Reports. Brookings, South Dakota. 1992 *SWINE 92*-1:1–4.

3. Danielson DM. *Proc Int Pig Soc Congress.* 1986.

4. Crenshaw MA, Danielson DM. Raw and processed soybeans in swine diets. In Miller ER, Ullrey DE, Lewis AJ, *eds. Swine Nutrition.* Stoneham, Massachusetts: Butterworth-Heineman. 1991; 573–584.

5. Young LG, et al. Effect of copper on the utilization of raw soybeans by marketing pigs. *Can J Anim Sci.* 1970; 50:717–730.

6. Crenshaw MA, Danielson DM. Raw soybeans for growing-finishing pigs. *J Anim Sci.* 1985;60(3):725–730.

7. Matzat PD, Miller ER, Hogberg MG. Value of raw soybeans in sow diets. *Report of Swine Research,* East Lansing, Michigan. 1985;469:19–21.

8. Crenshaw M, Danielson D. Raw soybeans for gestation and lactation diets. *Nebraska Swine Report.* Lincoln, NE. 1985;EC 85-219:27–29.

9. Hawton JD. Guidelines for feeding immature soybeans, low-test-weight corn and scabby wheat to swine. *Swine Research Report,* St. Paul, Minnesota. 1992.

10. Yen JT, Jensen AH, Simon J. Effect of dietary raw soybean and trypsin soybean inhibitor on trypsin and chymotrypsin activities in the pancreas and in small intestinal juices of growing swine. *J Nutr.* 1977;107(1):156–165.

11. Holden PJ. Nutritive value of light-test-weight corn for growing-finishing pigs. *Swine Day Report*, Ames, IA. 1975.

12. Patterson R, Tuitoek JK, Young LF. Nutritional value of immature corn of different bulk density for young pigs. *J Anim Sci.* 1993;71(Suppl 1):157.

13. Rozeboom DW, et al. *Animal Science Newsletter,* East Lansing, MI. 1993.

14. Thaler RC. Personal communication. 1995.

15. Thaler RC, et al. Feeding value of low-test-weight sorghum for growing-finishing pigs. *Proc SE Res Farm*. South Dakota State University. 1990;100.

Appendix A

Proper sampling techniques

When sampling either individual feedstuffs or processed complete feeds for laboratory analysis, it is essential to get a representative sample.

- If using a grain probe/trier to obtain samples from a mixer or bagged feed, take at least 10 0.5-lb samples per ton of feed from different locations and combine them into one composite sample for analysis.
- If sampling from an unloading auger, take at least 10 0.5-lb samples, split them in half, and send half of the composite samples in for analysis and store the properly labeled and dated other half in the freezer for reference.
- Use the same techniques when taking a grain sample to test for mycotoxins, except make sure the sample is sent to the lab in either a paper or cloth sack. Using plastic bags or metal cans may cause mold growth in transit.

For listing of certified labs, contact your state Extension Swine Specialist.