# SODIUM SULFITE AND EXTRUSION AFFECT THE NUTRITIONAL VALUE OF SOYBEAN PRODUCTS FOR NURSERY PIGS

*L. L. Burnham, J. D. Hancock, I.H. Kim, R. H. Hines, and T.L. Gugle*

## Summary

Extruded soybeans improved rates and efficiencies of gain when fed to nursery pigs in place of soybean meal (SBM). Sodium sulfite (an extrusion aid) increased extruder throughput and improved d 13 to 35 and overall efficiency of growth in pigs fed extruded soybeans and unextruded SBM. Further research is needed to determine if greater sodium sulfite concentrations will continue to increase extruder throughput and to elucidate the mechanism for improved growth performance of pigs fed sodium sulfite with unextruded SBM.

(Key Words: Nursery, Soybeans, Processing.)

## Introduction

Feeding whole soybeans to swine offers soybean producers an alternative to selling their crop, especially in years when poor growing conditions result in green soybeans with poor market value. On-farm or small-scale processing technologies available to producers include roasting and extruding. Roasting involves direct or indirect exposure of the soybeans to dry heat and has given mixed results in swine feeding experiments. Alternatively, extrusion consistently has been demonstrated to yield soybean products with equal or greater nutritional value than SBM, but the cost for processing soybeans can negate much of the benefit in pig performance. Thus, an extrusion aid (sodium sulfite) has been developed to increase extruder throughput and thereby, decrease the cost per ton of extruded soybeans. Little is known about the effects of sodium sulfite ($Na_2SO_3$) on nutritional value of extruded soybeans, and in last year's KSU Swine Day Report, we suggested improved nutritional value of diets when $Na_2SO_3$ was added even with no extrusion treatment. Thus, the experiment reported herein was designed to determine the optimum concentration of $Na_2SO_3$ for use when extruding soybeans. Also of interest was to verify the response we reported last year, that $Na_2SO_3$ may be of benefit in diets for weanling pigs even if not used as an extrusion aid.

## Procedures

The experiment was arranged in a 2 × 3 factorial with main effects of soybean product (SBM or extruded soybeans) and $Na_2SO_3$ (0, 15, or 30 lb/ton of soybean product). The dry-extruded whole soybeans (DEWS) treatments were processed in an Insta-Pro® dry extruder, with barrel temperatures of 298°F for the DEWS, 298°F for the DEWS + 15 lbs $Na_2SO_3$/ton of soy product, and 300°F for the DEWS + 30 lbs $Na_2SO_3$/ton of soy product.

Six pigs were allotted per pen and five pens per treatment. All diets were formulated to .92% lysine, .8% Ca, and .7% P for d 0 to 13 and .76% lysine, .8% Ca, and .7% P for d 13 to 35 (Table 1). The diets were formulated to be slightly deficient in lysine to emphasize differences in protein utilization among pigs fed the various treatments. Also, soybean oil was added to the diets with soybean meal, so that all diets had the same lysine:DE ratio.

The pigs were housed in an environmentally controlled nursery room with ad libitum access to feed and water. The pigs and feeders were weighed at d 0, 13, and 35 to allow calculation of ADG, ADFI, and F/G. Feces were collected from four pigs in each pen on d 12 and pooled for determination of apparent digestibilities of DM and N. The data were analyzed as a 2 × 3 factorial using the GLM procedure of SAS. Polynomial regression was used to determine linear and quadratic effects of $Na_2SO_3$ concentration.

## Results and Discussion

Chemical compositions of the soy products were similar to expected values, with slightly more than 48% CP in the SBM and 35 to 37% CP in the soybeans (Table 2). Likewise, crude fat, crude fiber, and amino acid concentrations were within normal ranges, with no marked effects of extruding on the chemical compositions of the soybean preparations.

As the concentration of $Na_2SO_3$ was increased to 30 lb/ton of soy product, extruder throughput was increased by 4% (Table 3). The improved extruder throughput probably resulted from the granular nature of the sulfite premix. That granular nature would contribute friction, thereby increasing mechanical energy and barrel temperature. Alternatively, we opened the annular gap die on the extruder barrel to maintain a constant processing temperature and increase extruded throughput.

For d 0 to 13 of the growth assay, treatment had no effect on ADG or ADFI ($P>.16$). Feed/gain became poorer as the concentration of $Na_2SO_3$ was increased for pigs fed SBM, with little response to increased concentrations of $Na_2SO_3$ when the pigs were fed DEWS (SBM vs DEWS × $Na_2SO_3$ quadratic interaction, $P<.03$). For d 13 to 35, pigs fed DEWS had better rates and efficiencies of gain than pigs fed SBM ($P<.001$). Also, F/G was improved ($P<.01$) with increasing concentration of $Na_2SO_3$.

The improved growth performance from use of DEWS in place of SBM is consistent with results we have published in previous KSU Swine Day Reports. However, $Na_2SO_3$ is marketed as an extrusion aid, and there is no obvious reason for the improved efficiency of gain with its addition to diets without extrusion.

For the entire experiment (d 0 to 35), pigs fed diets with DEWS had better ADG ($P<.003$) and F/G ($P<.002$) than pigs fed SBM. Addition of $Na_2SO_3$ did not affect ADG for the overall growth period, but increasing the concentration of $Na_2SO_3$ tended to improve F/G (linear effect, $P<.06$), especially when used for processing DEWS.

Digestibility of DM in SBM and DEWS tended to increase as concentration of $Na_2SO_3$ was increased, although maximum DM digestibility was observed with 15 lb $Na_2SO_3$/ton of soy product (quadratic effect, $P<.007$). Nitrogen digestibility also increased as $Na_2SO_3$ concentration was increased.

In conclusion, DEWS were superior to SBM as a protein source for nursery-age pigs. Also, adding $Na_2SO_3$ improved extruder throughput and efficiency of growth. However, the improvements with use of $Na_2SO_3$ were linear up to our greatest addition (i.e., 30 lb $Na_2SO_3$/ton of soy product), and additional research is needed to determine the greatest concentration that should be used.

**Table 1. Composition of Diets[a]**

| | d 0 to 13 | | d 13 to 35 | |
|---|---|---|---|---|
| Item, % | SBM[b] | DEWS[c] | SBM | DEWS |
| Corn | 48.67 | 48.67 | 63.53 | 63.53 |
| Soy product | 19.82 | 25.97 | 16.47 | 21.58 |
| Dried whey | 20.00 | 20.00 | 10.00 | 10.00 |
| Soybean oil | 1.98 | - | 1.66 | - |
| Cornstarch | 4.84 | .67 | 4.01 | .55 |
| Monocalcium phosphate | 1.83 | 1.68 | 1.62 | 1.50 |
| Limestone | .73 | .89 | .82 | .95 |
| Salt | .20 | .20 | .40 | .40 |
| Vitamin premix | .25 | .25 | .25 | .25 |
| Mineral premix | .15 | .15 | .15 | .15 |
| Zinc oxide | .35 | .35 | - | - |
| Copper sulfate | - | - | .09 | .09 |
| Antibiotic[d] | 1.00 | 1.00 | 1.00 | 1.00 |
| Sodium sulfite[e] | - | - | - | - |
| DL-methionine | .03 | .021 | - | - |
| Chromic oxide[f] | .15 | .15 | - | - |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |

[a]The diets were formulated to .92% lysine, .9% Ca, .8% P, and 1.56 Mcal DE/lb of diet from d 0 to 13 and .76% lysine, .8% Ca, .7% P, and 1.56 Mcal of DE/lb of diet from d 13 to 35.
[b]SBM = soybean meal.
[c]DEWS = dry-extruded whole soybeans.
[d]Provided 150 g of apramycin per ton of diet for d 0 to 13 and 50 g of carbadox per ton of diet for d 13 to 35.
[e]Sodium sulfite was added at the expense of cornstarch to give the 0, 15, and 30 lb/ton of soy product treatments.
[f]Used as an indigestible marker.

**Table 2. Characteristics of Soy Products**

| Item | SBM | Soybeans | DEWS | DEWS + 15 lb/ton of $Na_2SO_3$ | DEWS + 30 lb/ton of $Na_2SO_3$ |
|---|---|---|---|---|---|
| Extruder throughput, lb/h | - | - | 1,275 | 1,311 | 1,328 |
| Crude protein, % | 48.33 | 35.82 | 35.99 | 37.09 | 35.46 |
| Crude fat, % | .86 | 17.80 | 19.76 | 20.35 | 19.95 |
| Crude fiber, % | 3.96 | 9.18 | 9.54 | 9.92 | 9.43 |
| Amino acids, % of sample | | | | | |
| Arginine | 3.42 | 2.39 | 2.60 | 2.78 | 2.46 |
| Histidine | 1.28 | .96 | 1.01 | 1.06 | .97 |
| Isoleucine | 2.14 | 1.52 | 1.74 | 1.79 | 1.66 |
| Leucine | 3.75 | 2.71 | 2.92 | 3.05 | 2.79 |
| Lysine | 3.09 | 2.26 | 2.39 | 2.50 | 2.29 |
| Methionine | .70 | .53 | .56 | .59 | .53 |
| Phenylalanine | 2.47 | 1.77 | 1.89 | 1.97 | 1.81 |
| Threonine | 1.92 | 1.41 | 1.45 | 1.56 | 1.40 |
| Tryptophan | .62 | .42 | .48 | .49 | .45 |
| Valine | 2.34 | 1.69 | 1.83 | 1.85 | 1.78 |
| Trypsin inhibitor, mg/g | 2.05 | 12.98 | 1.66 | 2.09 | 1.49 |

Table 3. Effects of Sodium Sulfite on the Nutritional Value of Soybean Products for Nursery Pigs[a]

| | SBM[b] | | | DEWS[c] | | | | Contrasts[e] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | 0[d] | 15 | 30 | 0 | 15 | 30 | SE | 1 | 2 | 3 | 4 | 5 |
| d 0 to 13 | | | | | | | | | | | | |
| ADG, lb | .65 | .57 | .57 | .62 | .63 | .63 | .07 | -[f] | - | - | - | - |
| ADFI, lb | 1.06 | 1.06 | 1.00 | 1.05 | 1.07 | 1.07 | .04 | - | - | - | - | - |
| F/G | 1.63 | 1.86 | 1.75 | 1.69 | 1.70 | 1.70 | .03 | - | - | .09 | .01 | .03 |
| d 13 to 35 | | | | | | | | | | | | |
| ADG, lb | 1.00 | 1.01 | 1.01 | 1.10 | 1.09 | 1.11 | .03 | .001 | - | - | - | - |
| ADFI, lb | 2.16 | 2.05 | 2.01 | 2.17 | 2.10 | 2.08 | .05 | - | .04 | - | - | - |
| F/G | 2.16 | 2.03 | 1.99 | 1.97 | 1.93 | 1.87 | .02 | .001 | .01 | - | - | - |
| d 0 to 35 | | | | | | | | | | | | |
| ADG, lb | .87 | .84 | .84 | .92 | .92 | .93 | .02 | .003 | - | - | - | - |
| ADFI, lb | 1.75 | 1.68 | 1.64 | 1.76 | 1.72 | 1.71 | .04 | - | .07 | - | - | - |
| F/G | 2.01 | 2.00 | 2.00 | 1.91 | 1.87 | 1.84 | .02 | .002 | .06 | - | - | - |
| Digestibilities (d 12), % | | | | | | | | | | | | |
| DM | 82.4 | 86.2 | 84.8 | 82.0 | 84.7 | 83.1 | .9 | .11 | .07 | - | .007 | - |
| N | 74.4 | 82.3 | 78.6 | 77.6 | 76.6 | 78.9 | .3 | - | .05 | - | .09 | .004 |

[a]A total of 150 weanling pigs (avg initial wt of 13.2 lb) were allotted with six pigs per pen and five pens per treatment.
[b]SBM=soybean meal.
[c]DEWS=dry-extruded whole soybeans.
[d]Pounds of $Na_2SO_3$ per ton of soy product.
[e]Contrasts were: 1) SBM vs DEWS; 2) linear effect of $Na_2SO_3$; 3) SBM vs DEWS × linear effect of $Na_2SO_3$: 4) quadratic effect of $Na_2SO_3$; and 5) SBM vs DEWS × quadratic effect of $Na_2SO_3$.
[f]Dashes indicate P>.15.