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

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Summary

A total of 150 weanling pigs (14.2 lb avg body wt) was used in a 28-d growth assay to determine the effects of using sodium sulfite as an extrusion enhancer for soy products. Treatments were: 1) soybean meal (SBM), 2) SBM + sodium sulfite, 3) extruded SBM, 4) SBM extruded with sodium sulfite, 5) extruded whole soybeans, and 6) whole soybeans extruded with sodium sulfite. For d 0 to 14, pigs fed SBM had greater average daily feed intake (ADFI), although they had poorer efficiency of gain (F/G) than pigs fed the extruded soy products. Also, pigs fed sodium sulfite showed a trend for greater average daily gain (ADG) and F/G compared to pigs fed diets without sodium sulfite. The positive response to sodium sulfite continued into Phase II (d 14 to 28), where pigs fed sodium sulfite had greater ADG and ADFI compared to those not fed sodium sulfite. Pigs fed extruded soybeans in Phase II had greater ADG than pigs fed extruded SBM. Overall (d 0 to 28), pigs fed diets with sodium sulfite consumed more feed, gained faster, and tended to have improved efficiencies of gain compared to those fed diets without sodium sulfite. Also, pigs fed extruded soybeans had greater rates and efficiencies of gain than pigs fed extruded SBM. Thus, in conclusion, sodium sulfite improved growth performance of weanling pigs. Also, extruded soybeans supported greater growth performance than extruded SBM, but pigs fed extruded soybeans responded less to the use of sodium sulfite as an extrusion enhancement than pigs fed the other treatments.

(Key Words: Sodium Sulfite, Extrusion, Soybeans, Nursery Pigs, Performance.)

Introduction

Soybean meal is the most common protein source used in swine diets. However, soybeans and the meal left after the oil extraction process are also sources of various antinutritional factors such as trypsin inhibitors, lectins, and antigenic proteins (e.g., glycinin and β-conglycinin). Young pigs are especially susceptible to antinutritional factors because of limited feed intake and immature digestive tracts. Heat treatment is the process most commonly used to destroy antinutritional factors. However, the benefits of heating can be negated if the product is overcooked.

During extrusion, high temperature and pressure are used for a brief period to inactivate antinutritional factors without damaging the proteins. However, extrusion is a costly process. Previous experiments here at KSU have shown mixed results in performance of animals fed extruded soybean meal. Part of the inconsistent response may have been caused by overprocessing, i.e., heat treatment with extrusion processing in addition to the heat treatment (toasting) already applied to commercially processed soybean meal. Thus, an extrusion aid that reduces the amount of heat treatment needed to inactivate antinutritional factors could improve the nutritional value of soybean products. Additionally, such an extrusion aid could further increase the consistently good results we have observed with extruded whole soybeans. Sodium sulfite has been suggested as just such an aid for the extrusion process. Thus, the purpose of the experiment described herein was to determine if extrusion of soybean meal and whole soybeans with sodium sulfite improves growth performance and nutrient digestibility in weanling pigs.

Procedures

One hundred and fifty weanling pigs (average initial wt of 14.2 lb and average age of 21 d) were sorted by sex, weight, and ancestry and used in a 28-d growth assay. There were five pigs per pen with five pens per treatment. The pigs were housed in an environmentally controlled nursery with wire mesh flooring and had ad libitum access to feed and water. Treatments were: 1) soybean meal (SBM), 2) SBM + sodium sulfite, 3) extruded SBM, 4) SBM extruded with sodium sulfite, 5) extruded whole soybeans, and 6) whole soybeans extruded with sodium sulfite. The SBM and whole soybeans used in the experiment were mill-run. For the extrusion treatments, the SBM was mixed with 5% soybean oil prior to extrusion. The average barrel temperature was 290°F for extrusion of both the SBM and soybeans. Sodium sulfite (20 lb per ton) was thoroughly mixed into the SBM or ground whole soybeans before extrusion. As an additional control, 20 lb/ton of sodium sulfite was mixed into unextruded SBM to determine if the beneficial effects of sodium sulfite were caused by enhancement of the extrusion process or simply by addition of the sodium sulfite regardless of extrusion treatment.

The diets for Phase I (d 0 to 14) were formulated to .92% lysine, .9% Ca, and .8% P (Table 1). Diets for Phase II (d 14 to 28) were formulated to .76% lysine, .8% Ca, and .7% P (Table 2). The diets were deficient in lysine to accentuate treatment differences. All diets were formulated to the same digestible energy concentration (1.56 and 1.55 kcal/lb for Phases I and II, respectively) by adding soybean oil.

Pigs and feeders were weighed on d 0, 14, and 28 to allow calculation of ADG, ADFI, and F/G. Data were analyzed as a randomized complete block design. Treatment comparisons were made with the contrasts: 1) no sodium sulfite vs added sodium sulfite, 2) SBM vs extruded products, 3) extruded SBM vs extruded soybeans, 4) SBM vs extruded products × sodium sulfite, and 5) extruded SBM vs extruded soybeans × sodium sulfite.

Results and Discussion

During the initial postweaning phase (d 0 to 14), pigs fed SBM had the greatest ADFI ($P<.02$), but F/G was improved ($P<.03$) for pigs fed extruded SBM and soybeans (Table 3). Pigs fed diets with sodium sulfite tended to have greater rates and efficiencies of gain than pigs fed diets without sodium sulfite ($P<.09$).

For Phase II, pigs fed the diets with sodium sulfite had greater ADG, ADFI, and F/G compared to pigs fed the diets without sodium sulfite ($P<.03$). However, the response was not independent of extrusion treatment, with pigs fed extruded SBM responding to sodium sulfite as an extrusion aid, but pigs fed extruded soybeans not responding to use of sodium sulfite (interaction effect, $P<.04$ and $P<.05$ for ADG and F/G, respectively).

Responses similar to those observed in Phase I and II were noted for the entire experimental period (d 0 to d 28). Pigs fed soy products with added sodium sulfite had greater ADG and ADFI ($P<.002$ and $P<.04$, respectively), and with the exception of extruded soybeans, improved F/G ($P<.03$). Pigs fed soybeans extruded with sodium sulfite tended to have better growth performance than pigs fed soybeans extruded without sodium sulfite. However, as in Phase II, interactions occurred with use of sodium sulfite (i.e., pigs fed SBM but not soybeans responded to use of sodium sulfite as an extrusion aid).

Sodium sulfite is believed to enhance the extrusion process by cross-linking strands of denatured protein that form during extrusion, preventing them from returning to their globular state. The linear form of the proteins would be more accessible to digestive enzymes. The responses we observed to adding sodium sulfite before extrusion of SBM agrees with this theory. However, the response from simply adding sodium sulfite to the unextruded control diet, and the lack of response to extruded soybeans with sodium sulfite, leave questions about the actual mode of action for this extrusion aid. In conclusion, pigs fed diets with sodium sulfite tended to have improved ADG, ADFI, and F/G compared to pigs fed diets without sodium sulfite. Also, the extruded soybeans treatments tended to be of greater nutritional value than the extruded SBM treatments. However, further research is needed to define a mode of action for this proposed extrusion aid.

Table 1. Diet Composition for Phase I (d 0 to 14), %[a]

Ingredient	SBM	SBM + Na_2SO_3[b]	Extruded SBM[c]	Extruded SBM + Na_2SO_3[bc]	Extruded soybeans	Extruded soybeans + Na_2SO_3[b]
Corn	50.63	50.63	50.63	50.63	50.63	50.63
Soy product	19.40	19.40	20.00	20.00	25.00	25.00
Dried whey	20.00	20.00	20.00	20.00	20.00	20.00
Soybean oil	3.90	3.90	2.90	2.90	---	---
Cornstarch	1.60	1.60	2.00	2.00	---	---
Monocalcium phosphate	1.80	1.80	1.80	1.80	1.67	1.67
Limestone	.87	.87	.87	.87	.90	.90
Salt	.20	.20	.20	.20	.20	.20
Vitamins and minerals[d]	.40	.40	.40	.40	.40	.40
Copper sulfate	.10	.10	.10	.10	.10	.10
Antibiotic[e]	1.00	1.00	1.00	1.00	1.00	1.00
Chromic oxide	.10	.10	.10	.10	.10	.10
Total	100.00	100.00	100.00	100.00	100.00	100.00

[a]All diets were formulated to .92% lysine, .9% Ca, and .8% P.
[b]Sodium sulfite was MX PRO (Triple F Nutrition, Des Moines, IA), added at 20 lb/ton of extruded soy product.
[c]Extruded SBM had 5% soybean oil added before processing.
[d]KSU vitamin and mineral premixes.
[e]Supplied 50 g carbadox/ton of diet.

Table 2. Diet Composition for Phase II (d 14 to d 28), %[a]

Ingredient	SBM	SBM + Na_2SO_3[b]	Extruded SBM[c]	Extruded SBM + Na_2SO_3[bc]	Extruded soybeans	Extruded soybeans + Na_2SO_3[b]
Corn	58.24	58.24	58.24	58.24	58.24	58.24
Soy product	13.60	13.60	14.00	14.00	17.80	17.80
Dried whey	20.00	20.00	20.00	20.00	20.00	20.00
Soybean oil	2.90	2.90	2.20	2.20	---	---
Cornstarch	1.23	1.23	1.53	1.53	---	---
Monocalcium phosphate	1.40	1.40	1.40	1.40	1.30	1.30
Limestone	.83	.83	.83	.83	.86	.86
Salt	.20	.20	.20	.20	.20	.20
Vitamins and minerals[d]	.40	.40	.40	.40	.40	.40
Copper sulfate	.10	.10	.10	.10	.10	.10
Antibiotic[e]	1.00	1.00	1.00	1.00	1.00	1.00
Chromic oxide	.10	.10	.10	.10	.10	.10
Total	100.00	100.00	100.00	100.00	100.00	100.00

[a]All diets were formulated to .76% lysine, .8% Ca, and .7% P.
[b]Sodium sulfite was MX PRO (Triple F Nutrition, Des Moines, IA), added at 20 lb/ton of extruded soy product.
[c]Extruded SBM had 5% soybean oil added before processing.
[d]KSU vitamin and mineral premixes.
[e] Supplied 50 g carbadox/ton of diet.

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

Item	SBM	SBM + Na_2SO_3	Extruded SBM	Extruded SBM + Na_2SO_3	Extruded soybeans	Extruded soybeans + Na_2SO_3	CV
Phase I (d 0 to 14)							
ADG, lb[b]	.45	.46	.44	.51	.43	.48	13.3
ADFI, lb[c]	.93	.86	.85	.83	.71	.82	11.3
F/G[de]	2.07	1.87	1.93	1.63	1.65	1.71	11.3
Phase II (d 14 to 28)							
ADG, lb[fgh]	.78	1.00	.73	.95	.98	.97	13.5
ADFI, lb[i]	1.99	2.21	1.92	2.18	2.02	2.13	10.0
F/G[jkl]	2.56	2.21	2.63	2.29	2.06	2.20	11.0
Overall (d 0 to 28)							
ADG, lb[mno]	.62	.74	.59	.73	.71	.73	10.7
ADFI, lb[p]	1.46	1.53	1.38	1.51	1.37	1.48	8.6
F/G[qrs]	2.35	2.07	2.34	2.07	1.93	2.03	8.9

[a]A total of 150 weanling pigs (five pigs per pen and five pens per treatment) with an average initial body wt of 14.2 lb.

[begiknpr]Effect of sodium sulfite ($P < .08$, .09, .003, .02, .03, .002, .04, and .03, respectively).

[cd]SBM vs extruded products ($P < .02$ and .03, respectively).

[fjmq]Extruded SBM vs extruded soybeans ($P < .02$, .005, .08, and .01, respectively).

[hlos]Extruded SBM vs extruded soybeans × sodium sulfite ($P < .04$, .05, .07, and .03, respectively).