The effects of replacing dried distillers grains plus solubles with heat-treated soybean meal in forage-based growing calf diets

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Grady Gullickson, Madeliene Nichols, Yssi Entzie, Lydia Hansen, Sarah Underdahl, Lauren Hulsman Hanna, Colin Tobin, Kendall Swanson, and Zachary Carlson

North Dakota State University Department of Animal Sciences

Introduction

As the biodiesel industry expands, soybean-crushing plants are being built in North Dakota and surrounding states. These processing facilities extract soybean oil and produce feed byproducts such as soybean meal and soy hulls. The North Dakota Soybean Council estimates yearly crushing capacity at 136 million bushels and 940,000 tons of soybean meal. The increase in soybean meal production could allow producers to take advantage of a local feedstuff. Soybean meal (SBM) has a high protein content that offers a balanced amino acid profile, particularly lysine, for beef cattle diets. This could benefit producers in the Midwest as corn-based diets are typically limiting in the essential amino acid, lysine. However, SBM is highly degradable in the rumen at 70% rumen degradable protein (RDP; NASEM, 2016) so most of the lysine originally from SBM does not flow to the small intestine (Borucki Castro et al., 2007).

Increasing the rumen undegradable protein content in SBM through additional processes with non-enzymatic browning increases ruminal bypass that could improve cattle growth performance if protein and lysine requirements are not met (Coetzer et al., 1999). Heat-treated soybean meal (TSBM) supplies cattle with greater amounts of available amino acids, particularly lysine, and metabolizable protein (MP) by increasing the rumen undegradable protein (RUP) content to approximately 70%.

Objective and Hypothesis

Objective: To evaluate increasing concentrations of lysine and metabolizable protein by feeding heat-treated soybean meal in forage-based growing cattle diets.

Hypothesis: As heat-treated soybean meal replaces dried distillers grains plus solubles, growth performance will improve due to increased metabolizable protein and intestinal supply of essential amino acids.

Materials and Methods

The North Dakota State University Institutional Animal Care and Use Committee approved all animal procedures. Seventy Angus-based steers (initial BW = 656 ± 36 lb) were utilized in an 85-day growing study at the NDSU Beef Cattle Research Complex in Fargo, North Dakota. Steers originated from the NDSU Central Grasslands Research Extension Center. Steers were provided ad libitum access to feed and water in a monoslope barn with drylot access. Based on 16% inclusion of DDGS, dietary treatments using TSBM were formulated to replace DDGS at increasing inclusion levels of 0 (CON), 4 (TSBM4), 8 (TSBM), and 12% (TSBM12) dietary DM on a dry matter basis (Table 1). Diets were formulated using the empirical solutions model of the Beef Cattle Nutrient Requirements Model 2016 (version 1.0.37.15; NASEM, 2016) to increase metabolizable protein and lysine as the inclusion of TSBM increased in the diet. Lysine requirements in the formulated diets were predicted to be deficient for TSBM0 and TSBM4 treatments in excess for TSBM8 and TSBM12 treatments. In contrast, the metabolizable protein requirement was considered for all treatments (Table 2).

Prior to initiation of the study, steers were limit-fed a common diet containing 40% corn silage, 57% oat hay, and 3% dry meal supplement at 1.8% BW for five days followed by three days of weighing to minimize gut fill variation (Watson et al., 2013). The average of the 3-day weights served as the initial BW. Steers were blocked by weight into light (initial BW = 617 ± 14 lb), medium (initial BW = 653 ± 10 lb), and heavy (initial BW = 698 ± 18 lb) blocks and assigned randomly to treatments. The 3-day weight process was repeated at the end of the study to measure the ending BW. On day 0, steers were implanted with 80 mg of trenbolone acetate and 16 mg of estradiol (Revalor®-IS, Merck Animal Health, Summit, NJ). Body weights and blood were collected every 28 days. Blood was collected via jugular venipuncture, processed into plasma and serum samples, and stored at -4˚C until further analysis. Individual daily feed intake was measured using an automated feed system (Insentec Roughage Intake Control, Hokofarm B. V., Marknesse, The Netherlands).

Dietary dry matter DM was determined weekly by sampling ingredients and oven-drying at 60˚ C for 48 hours. Weekly ingredient samples were collected and ground through a 1 mm screen using a Wiley Mill grinder (Thomas Scientific, Swedesboro, NJ). Ground samples were composited into 4-week intervals. Composited ingredient samples were analyzed for laboratory DM, crude protein (CP), organic matter (OM), acid detergent fiber (ADF), neutral detergent fiber (NDF), starch, fat, calcium (C), and phosphorus (P).

Data were analyzed as a generalized randomized block design utilizing the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) with treatment (n = 4), period (n = 3), and treatment × period interaction as fixed effects, initial BW as a fixed covariate, and period considered a repeated measure using unstructured variance-covariance structure. Pairwise comparisons of significant model effects ($P \leq 0.05$) were adjusted using the Tukey-Kramer methods. Model residual plots were evaluated to ensure mixed procedure assumptions were met, and necessary outliers were removed.

Results and Discussion

While exploring statistical models on growth performance traits collected, two steers were identified as having data on all traits that were outliers compared to other steers (one from TSBM4 and one from TSBM8). Therefore, these two steers were removed from the analysis dataset, leaving sixty-eight steers with data available. Furthermore, initial models evaluating all possible interactions, including body weight block class effect with treatment and/or period, found that those interactions were sometimes significant. Environmental conditions are more likely to contribute to significance than treatment differences as steers performed inconsistently on the same treatment across blocks.

The interaction of treatment by period was significant ($P \leq 0.01$) for body weight (BW), average daily gain (ADG), and dry matter intake (DMI), with a tendency ($P = 0.10$) for feed:gain ratio (F:G). Pairwise comparisons of treatment within period did not differ ($P \geq 0.37$) for BW and DMI. However, from day 28 to 55, ADG was greater for TSBM4 than TSBM0 with TSBM8 and TSBM12 intermediates (Figure 1.). There were no differences ($P \geq 0.37$) in overall BW, ADG, DMI, and F:G ratio among treatments (Table 3).As TSBM replaced DDGS, the energy of the diet was likely less due to less digestible fiber and oil in TSBM than in DDGS. However, F:G ratio was not different among treatments, and while not statistically different, TSBM4 improved F:G ratio by 7.5% compared to TSBM0 (6.16 and 6.66, respectively). The formulated metabolizable lysine content for TSBM0 was deficient by 4.2 grams/day but TSBM4 was only deficient by 1.8 grams/day. Thus, metabolizable lysine was possibly limiting in the DDGS-only diet but was met when TSBM replaced 4% of the DDGS. However, because MP was provided above the requirement in all diets, it is possible that as TSBM replaced DDGS, the additional MP provided by TSBM was utilized as energy.

Conclusions

Our results agree with previous research when partially replacing wet corn distillers grains included at 20% of the diet with TSBM at 0, 6, and 12% dietary DM did not affect the growth performance of steers fed smooth brome hay-based diets (Spore et al., 2021). The results of the current study suggest that increasing concentrations of metabolizable protein and lysine through heat-treated soybean meal supplementation does not affect growing cattle performance with the partial replacement of DDGS when included at 16% of the diet. However, replacing dried distillers grains plus solubles with heat-treated soybean meal is an option if economically viable.

The new soybean crushing plants not only create more opportunities for soybean farmers but also livestock producers. Finding economical and nutritional feedstuffs could be the difference in profitability. The increase in soybean meal production in North Dakota could potentially give producers an additional protein option for feeding cattle.

Table 1. Experimental diets

Ingredient, % DM	TSBM0	TSBM4	TSBM8	TSBM12
Corn Silage	44	44	44	44
Oat Hay	37	37	37	37
DDGS[1]	16	12	8	4
TSBM[2]	0	4	8	12
Supplement[3]	3	3	3	3

[1]Dried Distillers Grains with Solubles.
[2]Heat-treated Soybean Meal (AminoPlus®, Ag Processing Inc., Omaha, NE).
[3]Supplement formulated to provide 22.9 g/ton monensin (Rumensin 90, Elanco Animal Health). Supplement contained 1.62% fine ground corn, 1.00% limestone, 0.30% salt, 0.05% beef trace mineral, 0.0126% Vitamin A, 0.002% Vitamin D, 0.0003% Vitamin E on dry matter basis.

Table 2. Nutrient composition of the experiment diets

Item	TSBM0	TSBM4	TSBM8	TSBM12
DM, % As-fed	46.90	46.90	46.90	46.90
CP, % DM	11.80	12.27	12.73	13.20
Fat, % DM	2.61	2.44	2.26	2.08
NDF, % DM	52.15	51.30	50.45	49.60
ADF, % DM	29.70	29.41	29.13	28.85
Starch, % DM	16.95	16.88	16.81	16.74
Metabolizable protein balance[1], g/d	60.7	89.2	110.2	137.9
Lysine balance[1], g/d	-4.94	-1.80	1.07	4.10

[1]Calculated utilizing the empirical solutions model of the Beef Cattle Nutrient Requirements Model 2016 (version 1.0.37.15; NASEM, 2016).

Table 3. Overall performance of growing cattle on forage-based diets with heat-treated soybean meal

	Treatments[1]					*P* - value		
Item	TSBM0	TSBM4	TSBM8	TSBM12	SEM	TRT	Period	TRT x Period
Steers, n	16	18	17	17	--	--	--	--
Initial BW, lb	656	656	656	656	3.8	0.99	--	0.99
Ending BW, lb	833	847	836	845	8.7	0.71	0.01	0.01
ADG, lb/day	2.09	2.26	2.13	2.24	0.101	0.54	0.01	0.04
DMI, lb/day	13.90	13.85	13.80	13.61	0.274	0.88	0.01	0.01
Feed:Gain	6.65	6.12	6.48	6.07	--	0.37	0.01	0.10

[1]Dietary percent of heat-treated soybean meal (TSBM) replacing a proportion of 16% dried distillers grains plus solubles in the diet; TSBM0: 0% heat-treated soybean meal, TSBM4: 4% heat-treated soybean meal, TSBM8: 8% heat-treated soybean meal, TSBM12: 12% heat-treated soybean meal.

[ab]Means with different superscripts in the same row differ ($P \leq 0.05$).

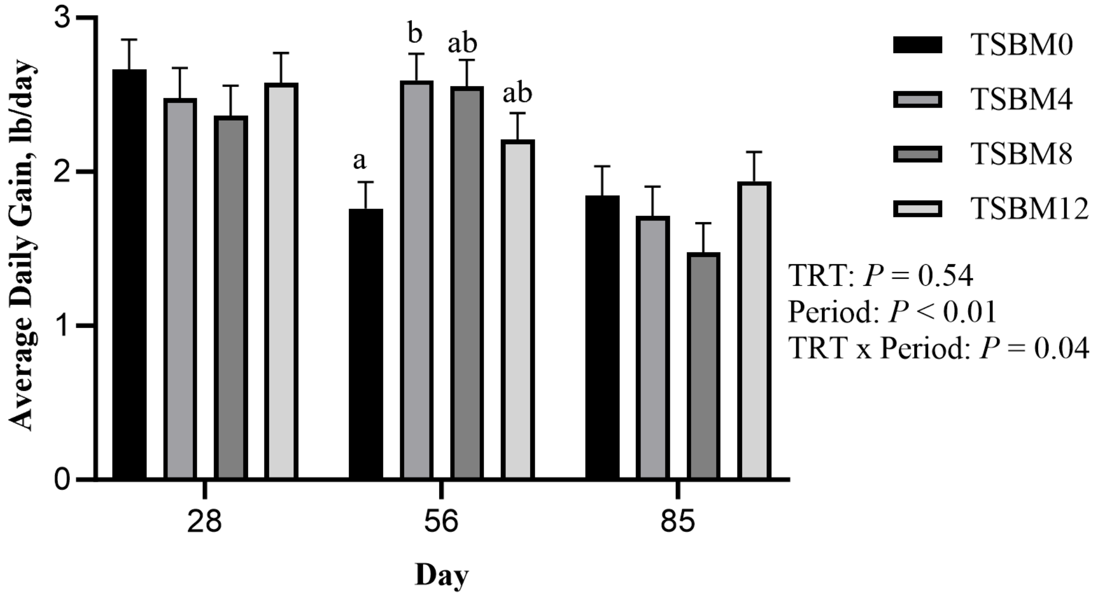

Figure 1. Effect of replacing 16% of diet dry matter distillers grains with solubles with heat-treated soybean meal (TSBM; 0, 4, 8, or 12% dry matter basis) in forage-based growing diets on average daily gain. [ab]Means with different superscripts within the same day differ ($P \leq 0.05$).