Evaluation of extruded and expelled soybean meal as a partial replacement for dried distillers grains plus solubles in diets offered to finishing beef steers

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Key findings:

- Feeding EESBM resulted in greater dry matter intake, daily gain and carcass weight compared to DDGS.
- Feeding EESBM did not influence measures of carcass quality or cutability.
- The replacement NE value of EESBM is 8.5 to 16.0% greater than DDGS.

Summary: This study evaluated the use of extruded and expelled soybean meal (EESBM) as a partial replacement (30 or 60% replacement) of dried distillers grains plus solubles (DDGS) in diets offered to finishing beef steers. Steers (n = 144 steers; 880 lbs initially) were used in 150 d feedlot finishing trial. Steers were group housed in 18 pens (n = 8 steers/pen) and allocated to one of three dietary treatments in a randomized complete block design (n =6 pens/treatment). Treatments included: 1) a finishing diet that included 15% DDGS; 2) a finishing diet that included 30% replacement of DDGS with EESBM, and 3) a finishing diet that included 60% replacement of DDGS with EESBM. Cattle were implanted with a 200 mg trenbolone acetate and 28 mg estradiol benzoate implant on d 28, however, no beta-adrenergic agonist was fed. Steers were fed twice daily and managed under conditions that mimic Northern Plains feedlot production systems. Dry matter intake linearly increased when EESBM replaced DDGS. Average daily gain and gain efficiency (both live basis shrunk 4% and from HCW/0.625), as well as hot carcass weight were linearly increased with greater inclusion of EESBM. No other carcass traits outcomes, nor the distribution of USDA Yield and Quality grade, lung scores or liver health outcomes were influenced by dietary treatment. In conclusion, EESBM in replacement of DDGS results in greater intake, improved efficiency, and greater final body weight and carcass weight with no detriment to carcass yield or quality outcomes.

Approach:

The animal care and handling protocols used in this study were approved by the South Dakota State University Institutional Animal Care and Use Committee #2311-007E. This study was conducted at the South Dakota State University Ruminant Nutrition Center (RNC) in Brookings, South Dakota between 09 February 2023 and 10 July 2023.

Dietary Treatments

This study used 18 pens of 8 steers/pen assigned to one of three dietary treatments in a randomized complete block design. Dietary treatments included:

1. A finishing diet that contained no EESBM (CON).
2. A finishing diet that contained EESBM at 30% replacement of DDGS (EE30).
3. A finishing diet that contained EESBM at 60% replacement of DDGS (EE60).

The EESBM evaluated in treatments 2 and 3 were included in the diet at 4.5% or 9.0%, respectively [dry matter (DM) basis].

Study Initiation and Dietary Management

One hundred and forty-four Continental × British crossbred steers [initial shrunk body weight (BW) = 882 ± 60.5 lbs] were used in a randomized complete block design to evaluate the influence of dietary replacement of DDGS with EESBM on finishing phase growth performance, efficiency of dietary NE utilization, comparative NE value, and carcass trait responses. All steers used in the experiment had previously been enrolled in separate receiving and backgrounding phase experiments conducted at the RNC. Steers had been vaccinated for viral respiratory pathogens (Bovi-Shield Gold 5, Zoetis, Parsippany, NJ), clostridial species (Ultrabac 7/Somubac, Zoetis), poured with moxidectin (Cydectin, Bayer Healthcare LLC, Shawnee Mission, KS) for the control of internal and external parasites, and administered a Synovex S (200 mg progesterone + 20 mg estradiol benzoate; Zoetis) approximately 90 d prior to initiation of the current study. On 09 February 2023, all steers were individually weighed to collect a BW for allotment purposes and poured with cyfluthrin (Cylence, Bayer Healthcare LLC) for control of external parasites. The following day, 10 February 2023, test diets were initiated. Steers were implanted on d 28 with a Synovex PLUS (200 mg trenbolone acetate + 28 mg estradiol benzoate; Zoetis).

Steers were housed in 625 ft^2 concrete surface pens with 7.62 m of linear bunk-space and provided *ad libitum* access to feed; bunks were managed to be slick at 0700 h most mornings. Diets were fortified to provide vitamins and minerals to meet or exceed nutrient requirements and provided monensin sodium at 30 g/ton of diet DM (NASEM, 2016). Fresh feed was manufactured twice daily in a stationary horizontal mixer (83 ft^3; Roto-Mix, Dodge City, KS; scale readability ± 1.0 lbs) and offered to steers in a 50:50 split at 0800 h and 1400 h. Individual ingredient samples were collected weekly and DM was calculated following drying in a 60°C forced air oven until no weight change to calculate dry matter intake (DMI). Actual diet formulation was based upon weekly DM analyses and corresponding feed batching records. Diets presented in Table 1 are actual DM formulation, tabular nutrient concentrations, and tabular energy values (Preston, 2016).

Health Management

All steers that were pulled from their home pen for health evaluation were then monitored in individual hospital pens prior to being returned to their home pens. When a steer was moved to a hospital pen the appropriate amount of feed from the home pen was removed and transferred to the hospital pen. Instances where the steer in the hospital pen was returned to the home pen, its feed remained credited to the home pen. If the steer did not return to their home pen, all feed delivered to the hospital pen was deducted from the feed intake record for that pen back to the date the steer was hospitalized. One steer enrolled in the EE30 treatment died, with the cause of death determined to be health anomalies not related to dietary treatment.

Study Termination, Harvest, and Carcass Data Collection

Cattle were weighed off test when they were visually appraised to have 0.60 in. of rib fat (RF). On the day of study termination cattle were shipped to Tyson Fresh Meats in Dakota City, NE and harvested the following morning. Steers were comingled at the time of study termination and remained as such until 0700 h the morning of harvest. Individual steer identity was tracked through the harvest facility using electronic identification tags. Hot carcass weight (HCW) was recorded during the harvest procedure. Video image data were obtained from the plant for ribeye area (REA), RF, and USDA marbling scores. Dressed yield (DP) was calculated as: (HCW/final BW shrunk 4%) x 100. Estimated empty body fat (EBF) percentage and final BW at 28% estimated empty body fatness (AFBW) were calculated from observed carcass traits (Guiroy et al., 2001); using a common kidney, pelvic and heart fat content of 2.5%. Yield grade (YG) was calculated according to the USDA regression equation (USDA, 2017). Estimated proportion of closely trimmed boneless retail cuts from the carcass round, loin, rib, and chuck (Retail Yield; RY) was also calculated from carcass traits (Murphey et al., 1960).

Cattle Growth Performance Calculations

Growth performance was calculated on a deads and removals excluded basis. Following study initiation, steers were individually weighed on d 1, 28, 70, 105, and 150 for the calculation of cumulative average daily gain (ADG) and feed conversion efficiency [gain:feed; (G:F)]. Live steer performance was calculated with a 4% shrink applied to initial and final BW to account for gastrointestinal tract fill. Dressing percentage was calculated as follows: [Hot carcass weight (HCW) ÷ Final shrunk BW] × 100. Cumulative carcass-adjusted growth performance was calculated from: HCW ÷ 0.625 (a common dressed yield of all steers in study).

Live-basis growth performance was used to calculate performance-based dietary NE to determine efficiency of dietary NE utilization. The performance based dietary NE was calculated from daily energy gain (EG; Mcal/d): EG = $(ADG)^{1.097} \times 0.0557^{.75}$; where W is the mean shrunk BW [kg; (NASEM, 1996)] from the feeding period. Maintenance energy (EM) was calculated by the equation: EM = 0.077 × median feeding shrunk $BW^{0.75}$. Dry matter intake is related to energy requirements and dietary NEm (Mcal/kg) according to the following equation: DMI = EG ÷ (0.877NEm – 0.41), and can be resolved for estimation of dietary NE for maintenance (NEm) by means of the quadratic formula $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2c}$, where a = 0.41EM, b = –0.877EM + 0.41DMI + EG, and c = –0.877DMI (Zinn and Shen, 1998). Dietary NE for gain (NEg) was derived from NEm using the following equation: NEg= 0.877NEm – 0.41 (Zinn and Shen, 1998).

The comparative NEm and NEg values EE60 was estimated using the replacement and substitution technique. Given that the NEm and NEg value of DDGS is 100 Mcal/cwt and 68 Mcal/cwt respectfully, the replacement NEm and NEg values for EE60 can be determined: EESBM NEm = [(EE60 NEm – CON diet NEm) ÷ EE60 inclusion] + 100 and EESBM ingredient NEg = [(EE60 NEg – CON diet NEg) ÷ EE60 inclusion] + 68, where inclusion of EE60 was 0.09 on a DM basis. Finally, in the case of the substitution technique, the NEm and NEg values for EESBM are determined as follows: NE EESBM = (NE EE60 diet – 0.91 NE CON diet)/ 0.09, where 0.91 and 0.09 are the proportions of CON diet and EESBM, respectively.

Statistical Analysis

Growth performance, carcass traits, and efficiency of dietary NE utilization were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. Distribution of USDA Yield and Quality grades were analyzed as binomial proportions in the GLIMMIX procedure of SAS 9.4. Both models included the fixed effects of dietary treatment and block was included as a random variable. Least squares means were generated using the LSMEANS statement of SAS 9.4. For all analyses, an α of 0.05 determined significance and an α of 0.06 to 0.10 was considered a tendency.

Results:

All growth performance and carcass trait responses are located in Table 2. No animals were removed from the study, however, one steer from EE30 died during the study due to reasons not related to dietary treatment.

Live-basis growth

Steers fed EESBM exhibited greater final BW (linear; $P = 0.04$) and ADG (linear; $P = 0.04$) compared to steers from CON. Feeding EESBM in replacement of DDGS tended (linear; $P = 0.07$) to increase daily DMI. However, feeding EESBM as a partial replacement of DDGS did not appreciable influence gain efficiency ($P = 0.11$).

Carcass-adjusted basis growth

Steers fed EESBM exhibited greater final BW (linear; $P = 0.02$) and ADG (linear; $P = 0.01$) compared to steers from CON. Feeding EESBM as a partial replacement of DDGS increased gain efficiency (linear; $P = 0.03$).

Applied energetics measures

Feeding EESBM did not appreciable influence ($P \geq 0.15$) measures of observed dietary energy. The replacement and substitution NE values for EESBM were 16 and 8.5% greater than DDGS.

Carcass traits, lung scores and liver outcomes

Feeding EESBM as a partial replacement of DDGS resulted in greater HCW (linear; $P = 0.04$) hot carcass weight and tended to increase estimated empty body fatness (linear; $P = 0.09$). No other carcass traits, or the distribution of USDA Yield or Quality grade, lung health score, nor liver health outcomes were influenced by feeding EESBM as a partial replacement of DDGS ($P \geq 0.17$).

Conclusion:

The use of EESBM as a partial replacement of DDGS resulted in greater dry matter intake, daily gain and carcass weight compared to DDGS. Feeding EESBM did not influence measures of carcass quality or cutability. The replacement NE value of EESBM is 8.5 to 16.0% greater than DDGS.

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Tables:

Table 1. Actual diet formulation fed and tabular nutrient content (all values except for DM on a DM basis)[1].

	d 1 to 42			d 43 to 126			d 127 to 150		
	CON	EE30	EE60	CON	EE30	EE60	CON	EE30	EE60
HMEC, %	82.44	82.25	82.06	21.37	21.32	21.27	19.15	19.12	19.09
LS[2], %	4.41	4.40	4.39	4.78	4.77	4.76	4.76	4.75	4.74
EESBM, %	0.00	4.17	8.31	0.00	4.53	9.04	0.00	4.52	9.03
DDGS, %	13.15	9.19	5.24	14.35	10.02	5.71	14.52	10.14	5.79
DRC, %	0.00	0.00	0.00	26.60	26.53	26.47	56.77	56.67	56.57
HMC, %	0.00	0.00	0.00	27.89	27.82	27.76	0.00	0.00	0.00
GH, %	0.00	0.00	0.00	5.01	5.00	4.99	4.80	4.79	4.78
DM, %	70.08	70.24	70.40	79.43	79.62	79.80	83.58	83.73	83.88
CP, %	11.81	12.61	13.40	12.83	13.70	14.56	12.88	13.74	14.59
NDF, %	18.85	17.83	16.82	17.21	16.11	15.01	16.98	15.87	14.76
ADF, %	9.63	8.97	8.31	8.81	8.09	7.37	8.66	7.93	7.20
Ash, %	4.87	4.90	4.94	5.11	5.15	5.18	5.09	5.12	5.16
EE, %	4.01	4.02	4.02	3.68	3.69	3.69	3.67	3.68	3.68
NEm, Mcal/cwt	89.16	89.18	89.21	93.49	93.51	93.53	93.26	93.27	93.28
NEg, Mcal/cwt	60.38	60.40	60.41	62.95	62.96	62.97	62.64	62.65	62.66

[1] HMEC = high-moisture ear corn; LS = molasses-based liquid supplement; EESBM = extruded and expelled soybean meal; DDGS = dried distillers grains plus solubles; DRC = dry-rolled corn; HMC = high-moisture corn; GH = grass hay; DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; EE = ether extract; NEm = net energy for maintenance; NEg = net energy for gain.

[2] Liquid supplement contained (DM basis): 44.46% CP, 38.78% non-protein nitrogen, 41 Mcal/cwt of NEm, 26 Mcal/cwt of NEg, 0.90% ether extract, 16.52% total sugars, 50.77% ash, 11.00% calcium, 0.38% P, 7.07% K, 0.13% Mg, 6.00% NaCl, 3.54% Na, 0.41% S, 4.30 ppm Co, 200.00 ppm Cu, 12.11 ppm I, 6.91 mg/lb EDDI, 525.35 ppm Fe, 404.93 ppm Mn, 2.93 ppm Se, 1,800 ppm Zn, 20,195.12 IU/lb Vitamin A, 201.95 IU/lb Vitamin E, and 585.37 g/ton monensin sodium

Table 2. Growth performance, carcass strait, lung and liver responses for the 150 d experiment with replacement of DDGS (15% inclusion) with extruded and expelled SBM (30 or 60% replacement of DDGS) in steers.[1]

	Treatment				*P* - value		
	CON	EE30	EE60	SEM	Overall	Linear	Quadratic
Steers, n	48	47	48	-	-	-	-
Pens, n	6	6	6	-	-	-	-
Initial BW, lbs	880	880	880	1.1	0.81	1.00	0.52
Live-basis							
Final BW, lbs	1415	1422	1447	14.0	0.10	0.04	0.47
ADG, lbs	3.57	3.61	3.78	0.091	0.09	0.04	0.43
S.D. ADG	0.319	0.315	0.336	0.0484	0.90	0.73	0.77
DMI, lbs	22.99	22.81	23.72	0.353	0.06	0.07	0.10
G:F	0.155	0.158	0.159	0.0024	0.24	0.11	0.62
F:G[2]	6.45	6.33	6.29	-	-	-	-
Carcass-adjusted basis							
HCW/0.625, lbs	1480	1489	1516	12.3	0.04	0.02	0.41
ADG, lbs	4.00	4.06	4.24	0.079	0.03	0.01	0.37
DMI, lbs	22.99	22.81	23.72	0.353	0.06	0.07	0.10
G:F	0.174	0.178	0.179	0.0019	0.07	0.03	0.39
F:G[2]	5.75	5.62	5.59	-	-	-	-
Applied Energetics[3]							
NEm, Mcal/cwt	92.43	93.62	93.60	0.757	0.25	0.15	0.38

NEg, Mcal/cwt	62.47	63.51	63.49	0.664	0.25	0.16	0.38
O/E NEm	1.00	1.02	1.02	0.008	0.26	0.19	0.32
O/E NEg	1.01	1.02	1.02	0.011	0.28	0.17	0.41
Replacement NEm, Mcal/cwt	-	-	113.00	-	-	-	-
Replacement NEg, Mcal/cwt	-	-	79.33	-	-	-	-
Substitution NEm, Mcal/cwt	-	-	106.43	-	-	-	-
Substitution NEg, Mcal/cwt	-	-	73.80	-	-	-	-
Carcass traits							
HCW, lbs	925	931	947	7.6	0.04	0.02	0.41
DP[4], %	65.39	65.44	65.49	0.184	0.87	0.61	0.99
REA, in sq.	14.13	14.31	14.31	0.306	0.79	0.56	0.73
RF, in	0.59	0.58	0.62	0.024	0.20	0.17	0.22
Marbling[5]	491	501	506	14.6	0.59	0.32	0.87
Yield Grade	3.46	3.40	3.57	0.123	0.37	0.37	0.28
Retail Yield[6], %	49.12	49.25	48.89	0.255	0.39	0.38	0.29
EBF[7], %	31.56	31.49	32.21	0.350	0.12	0.09	0.23
AFBW[7], lbs	1321	1331	1331	15.9	0.77	0.55	0.70
Yield Grade, %							
1	0.0	2.1	2.1	-	0.32	-	-
2	33.3	42.5	27.1				
3	62.5	44.7	60.4				
4	4.2	8.5	10.4				
5	0.0	2.2	0.0				

Quality Grade, %							
Select	10.4	6.5	10.6	-	0.94	-	-
Low Choice	47.9	52.2	48.9				
Upper Choice	39.6	39.1	38.3				
Prime	2.1	2.2	2.2				
Lung Score[8], %							
0	81.3	80.9	75.0	-	0.68	-	-
1	8.3	17.0	12.5				
2	2.1	2.1	12.5				
3	2.1	0.0	0.0				
4	4.2	0.0	0.0				
5	2.0	0.0	0.0				
Liver outcomes[8], %							
Normal	95.8	97.9	87.5	-	0.14	-	-
A-	0.0	2.1	6.2				
A	0.0	0.0	2.1				
A+ or Greater	4.2	0.0	4.2				

[1] All BW measures were shrunk 4% to account for gastrointestinal tract fill.

[2] Calculated as 1/G:F.

[3] Calculated using live-basis growth performance shrunk 4%

[4]Dressing percentage was calculated as: hot carcass weight/(final BW × 0.96).

[5]400=small[00]

[6]Proportion of closely trimmed boneless retail cuts from carcass round, loin, rib, and chuck were determined according to the equation described by (Murphey et al., 1960).

[7] Estimated empty body fat (EBF) percentage from observed carcass traits (Guiroy et al., 2001).

[7] Final shrunk body weight adjusted to 28% EBF (AFBW) according to Guiroy et al. (2001).

[8] Individual lungs were evaluated according to the scale described by (Mayer et al., 2022). 0 = normal; 1 = presence of mycoplasma-like lesion > 15%; 2 = plural adhesions, a portion of the lung missing, or a combination of these affecting <25% of lung tissue; 3 = plural adhesions, a portion of the lung missing, or a combination of these affecting >25 to < 50 % of lung tissue; 4 = plural adhesions, a portion of the lung missing, or a combination of these affecting >50 to < 75 % of lung tissue; 5 = plural adhesions, a portion of the lung missing, or a combination of these affecting >75 % of lung tissue. Liver abscess prevalence and severity was determined by a trained technician using the Elanco system as Normal (no abscesses), A- (1 or 2 small abscesses or abscess scars), A (2 to 4 well organized abscesses less than 1 in. diameter), or A+ (1 or more large active abscesses greater than 1 in. diameter with inflammation of surrounding tissue).