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Effects of increasing soybean hulls in finishing diets with wet or modified distillers grains plus solubles on performance and carcass characteristics of beef steers

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ABSTRACT

Two experiments evaluated feeding soybean hulls (SBH) in finishing diets that contain distillers grains plus solubles on performance and carcass characteristics. Dietary concentrations of SBH were 0, 12.5, 25, and 37.5% of diet DM. In Exp. 1, 167 crossbred yearling steers (395 ± 22 kg of BW) were fed for 117 d in a randomized block design in which pelleted SBH replaced dry-rolled corn. All diets contained 25% modified distillers grains plus solubles, 15% corn silage, and 5% liquid supplement. As SBH concentration increased, DMI decreased linearly (P = 0.04). Gain and G:F decreased linearly (P < 0.01) in response to increasing concentrations of SBH, which decreased relative energy value from 91 to 79% of corn. Hot carcass weight linearly decreased (P < 0.01) by 24 kg as SBH increased. In Exp. 2, a randomized block design used 160 backgrounded steer calves (363 ± 16 kg of BW) in a 138-d finishing study with 0, 12.5, 25, or 37.5% SBH in the meal form. Basal ingredients consisted of a 1:1 ratio of high-moisture corn and dry-rolled corn, 40% wet distillers grains plus solubles, 8% sorghum silage, and 4% dry meal supplement. There was a tendency (P = 0.12) for a quadratic increase in ADG and G:F as dietary SBH increased, with numerically greatest ADG and G:F with 12.5% SBH. Feeding 12.5 to 25% SBH with 40% wet distillers grains plus solubles (Exp. 2) had little effect on performance but decreased ADG and G:F in diets with 25% modified distillers grains plus solubles (Exp. 1).

Key words: distillers grains plus solubles, finishing cattle, performance, soybean hulls

INTRODUCTION

In 2015 the USDA reported that 81.1 million acres of soybeans were planted, producing over 3.93 billion bushels of soybeans in the United States (NASS, 2016). Sessa and Wolf (2001) reported the soybean hull (**SBH**) represents 8% of the total weight of soybean DM. Traditionally, the hull was blended with soybean meal, resulting in soybean meal containing 44% CP. Today the poultry and swine industries use 70 to 75% of soybean meal produced in the United States (American Soybean Association, 2011) and because of the limited ability of these animals to digest fiber (Van Soest, 1994), smaller quantities of SBH are blended into soybean meal. Thus, more SBH are available to be used as cattle feed.

As an alternative energy source to cereal grains in forage diets, SBH have been shown to have an energy

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value equal to or greater than that of corn (Anderson et al., 1988; Garcés-Yépez et al., 1997). Similarly, Swanson et al. (2007) observed no difference in animal performance between SBH and cracked corn when included in backgrounding diets for beef cattle. Feeding SBH with a combination of wet corn gluten feed and wet distillers grains plus solubles (**WDGS**) to steers resulted in ADG and feed efficiency being poorest in finishing diets replacing corn with SBH (Wilken et al., 2009). However, to our knowledge, no data exist evaluating the effects of replacing corn with SBH in finishing diets containing WDGS. Therefore, 2 experiments were conducted to determine the optimum concentration of SBH in a feedlot finishing diet with distillers grains and to assess the feeding value of SBH relative to corn.

MATERIALS AND METHODS

All facilities and procedures were approved by the University of Nebraska Institutional Animal Care and Use Committee (IACUC 517 and 525).

Exp. 1

A total of 168 crossbred yearling steers (average BW = 395 ± 22 kg) were used in a randomized block design, 117-d finishing trial. Steers were purchased at a local auction barn and received at the University of Nebraska–Lincoln Haskell Agricultural Laboratory (near Concord, NE) research feedlot during the fall of 2011. Initial processing included vaccination for infectious bovine rhinotracheitis, bovine viral diarrhea, parainfluenza-3, bovine respiratory syncytial virus, *Mannheimia haemolytica*, and *Pasteurella multocida* (Vista Once SQ; Merck Animal Health, Summit, NJ); prevention of *Clostridium chauvoei*, *Clostridium septicum*, *Clostridium novyi*, *Clostridium sordellii*, and *Clostridium perfringens* (Vision 7; Merck Animal Health); administration of an insecticidal pour-on (Exile Ultra; Agripharm Products, Westlake, TX); and insertion of a panel tag for identification. Steers were limit fed a diet consisting of 40% dry-rolled corn (**DRC**), 20% modified distillers grains plus solubles (**MDGS**; ADM, Columbus, NE; DM of 57.2%), 20% pelleted SBH (ADM, Fremont, NE), 15% corn silage, and 5% supplement (DM basis) at 2% of BW for 4 d to limit gut fill variation (Watson et al., 2013). Steers were individually weighed on d 0 and 1, and then weights were averaged to establish initial BW (Stock et al., 1983). Cattle were blocked by d-0 BW into 3 blocks (light, medium, heavy), stratified by BW within block, and assigned randomly to 1 of 24 pens. Light, medium, and heavy weight blocks consisted of 2 replications each. Pens were assigned randomly to 1 of 4 treatments with 7 steers per pen and 6 pens per treatment.

Dietary treatments (Table 1) consisted of SBH fed at 0, 12.5, 25, or 37.5% of diet DM replacing DRC. Cattle were adapted to a high energy concentrate diet over a 25-d period before limit feeding; therefore, cattle were fed their respective finishing diet on d 1. All finishing diets included 25% MDGS, 15% corn silage, DRC, and 5% liquid supplement (Liquid Feed Commodities Co., Fremont, NE). The liquid supplement was formulated to contain 31.9 mg of monensin/kg of diet DM and to provide 90 mg of tylosin per steer daily (Elanco Animal Health, Greenfield, IN).

Cattle were fed once daily at approximately 0800 h. Bunks were evaluated daily and managed so that only trace amounts of feed were present at time of feeding. When refusals were present; orts were weighed, sampled, frozen, and later analyzed for DM. Dry matter was determined by placing samples in a 60°C forced-air oven for 48 h (AOAC, 1965; Method 935.29). Soybean hulls were sampled monthly, composited, and used for subsequent analysis. Ingredient CP was analyzed using a combustion chamber (AOAC, 1965; Method 990.03; TruSpec N Determinator, Leco Corporation, St. Joseph, MI). Ingredient NDF was determined using the procedure defined by Van Soest et al. (1991). Ether extract was determined using a biphasic lipid extraction procedure described by Bremer (2010). The nutrient composition of SBH was 57% NDF, 13.2% CP, and 3.8% ether extract (DM basis). Nutrient compositions for DRC, MDGS, and corn silage were obtained from the NRC (1996).

Table 1. Ingredient and chemical compositions of diets (DM basis) fed to finishing steers evaluating increasing concentrations of soybean hulls (SBH) with modified distillers grains plus solubles (Exp. 1)

	SBH inclusion,[1] % of diet DM			
Item, %	0	12.5	25	37.5
Dry-rolled corn	55.0	42.5	30.0	17.5
Modified distillers grains plus solubles	25.0	25.0	25.0	25.0
Soybean hulls (SBH)	—	12.5	25.0	37.5
Corn silage	15.0	15.0	15.0	15.0
Liquid supplement[2]	5.0	5.0	5.0	5.0
Calculated nutrient composition				
NDF	21.1	27.1	33.1	39.1
CP	14.0	14.4	14.9	15.3
Ether extract	5.4	5.3	5.2	5.2

[1]Dietary treatment concentration of SBH.

[2]Supplement formulated to provide 31.9 mg of monensin/kg of diet and 90 mg of tylosin per steer daily (Elanco Animal Health, Greenfield, IN). Supplement contained a minimum of 15% CP, 8.0% Ca, 3.0% K, 2.0% salt, 0.21% P, 0.01% crude fat, and 0.01% crude fiber; a maximum of 9.0% Ca and 3.0% salt; and 6,182 IU of vitamin A, 1,227 IU of vitamin D, and 1.5 IU of vitamin E/kg.

Steers were implanted with Revalor-S (120 mg of trenbolone acetate and 40 mg of estradiol-17β; Merck Animal Health) on d 0 and slaughtered on d 118 at Greater Omaha Packing Co. (Omaha, NE). Hot carcass weights were recorded on d 118. After a 48-h chill, USDA marbling score, 12th rib fat depth, and LM area were recorded. A common DP of 63% was used to calculate carcass adjusted performance to determine final BW, ADG, and G:F. A constant KPH of 2.5% was assumed and used in the USDA YG calculation of Boggs and Merkel (1993). At the 0% SBH inclusion, one steer died from an umbilical abscess.

The NRC (1996) model was used to predict animal performance based on dietary energy content and intake. With input variables of diet composition, initial BW, final BW, ADG, and DMI known, the energy value of SBH relative to corn was calculated for each pen. Total digestible nutrients were assumed to be 90% for corn (NRC, 1996), 72% for corn silage (NRC, 1996), and 112.5% for MDGS (Bremer et al., 2011) in all diets. The NE adjusters for the 0% SBH diet were adjusted to equal the observed ADG for that treatment. The NE adjusters were held constant at 79% for evaluation of SBH treatments. With NE adjusters held constant, the percent TDN value for SBH was adjusted until the observed ADG for each pen was obtained using observed DMI. The energy value was then calculated by taking the percent TDN value of SBH divided by percent TDN of corn for each treatment.

The feeding value (Klopfenstein et al., 2008) of SBH relative to corn was also calculated for each concentration of SBH using feed efficiency. The difference between each SBH concentration and the 0% treatment were calculated, divided by the feed efficiency of the 0% SBH, divided by the decimal percentage of concentration of SBH, and multiplied by 100 to get a feeding value of SBH relative to corn for each SBH concentration.

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). Pen was the experimental unit and block was treated as a fixed effect. Orthogonal contrasts were constructed to determine the response curve (linear, quadratic, and cubic) for SBH concentration in the diet. Differences were considered significant when $P \leq 0.05$, and a tendency was considered when differences were between $P > 0.05$ and $P \leq 0.15$.

Exp. 2

A total of 160 backgrounded steer calves (average BW = 363 ± 16 kg) were used in a randomized block design experiment. The 138-d finishing trial was conducted at the University of Nebraska Agricultural Research and Development Center (near Mead, NE) in the spring of 2012. Before the current experiment, steers were received into feedlot pens and used in a 30-d receiving study. After the receiving study, steers were placed on a common diet consisting of Sweet Bran (Cargill Corn Milling, Blair, NE), cornstalks, and wheat straw for 15 d. Upon arrival to the feedlot, initial processing of steers included vaccination for infectious bovine rhinotracheitis, bovine viral diarrhea, parainfluenza-3, and bovine respiratory syncytial virus (Bovi-Shield GOLD 5; Zoetis Animal Health, New York, NY); prevention of *Haemophilus somnus* (Somubac; Zoetis Animal Health) and *Mannheimia haemolytica* (One Shot; Zoetis Animal Health); administration of a parasiticide injection (Dectomax; Zoetis Animal Health); and individual identification (panel tag, metal tag, and electronic ear button). Approximately 2 wk later, cattle were revaccinated with Bovi-Shield GOLD 5 (Zoetis Animal Health), Vision 7 (Merck Animal Health), and *Moraxella bovis* (Piliguard Pinkeye Triview; Merck Animal Health). Before initiation of the trial, steers were limit fed at 2% of BW a diet consisting of 50% Sweet Bran and 50% alfalfa hay for 5 d to minimize variation in gastrointestinal fill. Cattle were weighed and assigned randomly to 1 of 20 pens using the same method as described in Exp. 1. Light, medium, and heavy blocks consisted of 1, 2, and 2 replications, respectively. Pens were assigned randomly to 1 of 4 treatments with 8 steers per pen and 5 pens per treatment.

Dietary treatments (Table 2) consisted of ground SBH (Bunge, Council Bluffs, IA) at 0, 12.5, 25, and 37.5% of diet DM replacing a 1:1 blend of DRC and high-moisture corn. All finishing diets contained 40% WDGS (BioFuel Ethanol Energy Corp., Wood River, NE), 8% sorghum silage, and 4% dry meal supplement. The supplement was formulated to contain 33 mg of monensin/kg of diet DM (Rumensin, Elanco Animal Health) and to provide 90 mg of tylosin per steer daily (Tylan, Elanco Animal Health). Adaptation to the final finishing diets consisted of a 17-d period and 4 adaptation diets fed 3, 4, 5, and 5 d, respectively, by increasing the inclusion of corn blend and SBH, while decreasing the quantity of sorghum silage in the diet. For step 1, sorghum silage was fed at 35% of DM and decreased by 7% for each subsequent step, except by 6% when transitioning from step 4 to the finisher diet. For steers fed 12.5% SBH, step 1 consisted of SBH at 5.5% of DM then increasing to 12.5% at step 2. Soybean hulls were introduced at 20% of DM in step 1 for treatment groups 25 and 37.5% SBH. For steers fed 25% SBH, step 2 included SBH at 25% of DM. Soybean hulls were increased by 8, 7, and 2.5% of DM during steps 2, 3, and 4 for steers fed 37.5% SBH. In all treatments, the supplement for step 1 was provided at 5% DM of the diet but was included at 4% throughout the remainder of the feeding period. Wet distillers grains plus solubles was included in the diet at 40% of DM in all steps. Bunks were evaluated daily at 0600 h for the presence of feed and managed as described in Exp. 1 with steers being fed once daily at approximately 0800 h. Feed refusals were weighed, sampled, and dried in a forced-air oven for 48 h at 60°C for DM determination (AOAC, 1965: Method 935.29). Soybean hulls and ingredients were sampled weekly and composited by month, and

Table 2. Ingredient and chemical compositions of diets (DM basis) fed to finishing steers evaluating increasing concentrations of soybean hulls (SBH) with wet distillers grains plus solubles (Exp. 2)

	SBH inclusion,[1] % of diet DM			
Item, %	0	12.5	25	37.5
Dry-rolled corn	24.00	17.75	11.50	5.25
High-moisture corn	24.00	17.75	11.50	5.25
Wet distillers grains plus solubles	40.00	40.00	40.00	40.00
SBH	—	12.50	25.00	37.50
Sorghum silage	8.00	8.00	8.00	8.00
Dry supplement[2]				
Fine ground corn	2.06	2.06	2.06	2.06
Limestone	1.43	1.43	1.43	1.43
Salt	0.30	0.30	0.30	0.30
Tallow	0.13	0.13	0.13	0.13
Beef trace mineral[3]	0.05	0.05	0.05	0.05
Vitamin A-D-E[4]	0.02	0.02	0.02	0.02
Rumensin-90[5]	0.02	0.02	0.02	0.02
Tylan-40[6]	0.01	0.01	0.01	0.01
Calculated nutrient composition				
NDF	22.7	28.6	34.6	40.5
CP	16.6	17.1	17.6	18.2
Ether extract	5.2	5.2	5.2	5.2

[1]Dietary treatment concentrations of SBH.

[2]Supplement formulated to be fed at 4% of diet DM.

[3]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, and 0.05% Co.

[4]Premix contained 1,500 IU of vitamin A, 3,000 IU of vitamin D, and 3.7 IU of vitamin E per gram.

[5]Premix contained 198 g of monensin/kg; formulated to provide 33 mg of monensin/kg of diet. Elanco Animal Health (Greenfield, IN).

[6]Premix contained 88 g of tylosin/kg; formulated to provide 90 mg of tylosin per steer daily. Elanco Animal Health.

subsequent analyses were performed as described in Exp. 1. The nutrient composition of SBH was 58% NDF, 12.9% CP, and 3.7% ether extract. Nutrient compositions for DRC, high-moisture corn, WDGS, and sorghum silage were obtained from the NRC (1996).

Steers were implanted on d 1 with Revalor-IS (80 mg of trenbolone acetate and 16 mg of estradiol-17β; Merck Animal Health), re-implanted with Revalor-S (120 mg of trenbolone acetate and 24 mg of estradiol-17β; Merck Animal Health) on d 47, and slaughtered at Greater Omaha Packing Co. on d 139. Carcass measurements were taken in the same manner as described in Exp. 1. Two steers died due to bloat, one fed 0% and one fed 37.5% SBH; 2 steers were removed from the study (one each on 25 and 37.5% SBH) due to chronic bloating. These steers were not included in the analysis of performance data.

The calculated energy values and feeding values of SBH relative to corn were calculated in the same manner as described in Exp. 1. Total digestible nutrients were assumed to be 90% for DRC (NRC, 1996), 93% for high-moisture corn (NRC, 1996), 60% for sorghum silage (NRC, 1996), and 117% for WDGS (Bremer et al., 2011) in all diets. The NE adjusters for the 0% diet were adjusted to equal observed ADG for that treatment. The NE adjusters were set at 77.6% based on performance of the 0% diet. Treatments were then evaluated where TDN of SBH was modified to equal observed ADG after setting observed DMI.

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Institute Inc.) with removed animals (dead or chronic) not included in the analysis. Pen was the experimental unit and block was treated as a fixed effect. Orthogonal contrasts were constructed to determine the response curve (linear, quadratic, and cubic) for SBH concentration in the diet. Differences were considered significant when $P \leq 0.05$, and a tendency was considered when differences were between $P > 0.05$ and $P \leq 0.12$.

RESULTS AND DISCUSSION

In Exp. 1, final BW decreased linearly ($P < 0.01$) as concentration of SBH increased (Table 3). Steers fed 37.5% SBH were 39 kg lighter than those fed 0% SBH. Similarly, final BW tended ($P = 0.12$) to decrease linearly with increasing concentration of SBH in Exp. 2 (Table 4). In contrast, Ludden et al. (1995) replaced dry cracked corn with SBH (0, 20, 40, or 60% of diet DM) in finishing diets and observed no difference in final BW. In Exp. 1, as SBH concentration increased, DMI decreased linearly ($P = 0.04$). As dietary concentration of SBH increased from 0 to 37.5%, DMI decreased from 12.2 to 11.7 kg/d. However, inclusion of SBH in the diet had no effect ($P \geq 0.18$) on DMI in Exp. 2, which would agree with Hsu et al. (1987). Conversely, Ludden et al. (1995) observed a linear increase in DMI as dietary SBH concentration increased. Average daily gain decreased linearly ($P < 0.01$) as SBH replaced corn in Exp. 1, which would agree with Ludden et al. (1995). A 4.3% decrease in ADG was observed between 0 and 12.5% SBH, and a 17.5% decrease was observed between 0 and 37.5% SBH. For Exp. 2, there was a tendency ($P = 0.12$) for a quadratic increase in ADG as concentration of SBH increased in the diet. Average daily gain was greatest at 12.5% SBH (1.83 kg/d), which

Table 3. The effects of soybean hull (SBH) inclusion on finishing cattle performance and carcass characteristics when fed with modified distillers grains plus solubles (Exp. 1)

	SBH inclusion,[1] % of diet DM					*P*-value	
Item	0	12.5	25	37.5	SEM	Linear[2]	Quadratic[3]
Performance							
Initial BW, kg	394	395	396	396	2	0.23	0.92
Final BW,[4] kg	619	609	604	580	11	<0.01	0.19
DMI, kg/d	12.2	12.1	12.2	11.7	0.2	0.04	0.10
ADG, kg	1.91	1.83	1.78	1.58	0.10	<0.01	0.19
G:F, kg/kg	0.158	0.152	0.146	0.134	0.003	<0.01	0.37
Energy value,[5] %		91	86	79	4	<0.01	0.28
Feeding value,[6] %		69.6	69.6	59.5			
Carcass characteristics							
HCW, kg	390	384	381	366	7	<0.01	0.18
Marbling[7]	591	585	564	566	11	0.07	0.75
LM area, cm^2	83.55	84.64	84.06	82.58	1.23	0.54	0.31
12th rib fat, cm	1.24	1.19	1.22	1.22	0.08	0.78	0.82
Calculated YG[8]	3.48	3.29	3.20	2.98	0.11	<0.01	0.90

[1]Dietary treatment concentrations of SBH.
[2]*P*-value for the linear response to SBH inclusion.
[3]*P*-value for the quadratic response to SBH inclusion.
[4]Calculated from carcass weight, adjusted to 63% common DP.
[5]Percentage relative to corn, calculated from percent TDN of SBH, divided by percent TDN of corn (90%).
[6]Percentage of corn feeding value calculated as percent difference in G:F from control divided by inclusion rate.
[7]Marbling score: 400 = Slight, 500 = Small, 600 = Modest, and so on.
[8]YG = 2.50 + (6.35 × fat thickness, cm) + (0.2 × KPH, %) + (0.0017 × HCW, kg) − (2.06 × LM area, cm^2).

resulted in a 3.8 and 9.2% increase in ADG compared with concentrations of 0 and 37.5%, respectively. Anderson and Schoonmaker (2005) reported a similar response in ADG as Exp. 2, with gains being greatest for steers fed 12.5% SBH. In Exp. 1, feed efficiency decreased linearly ($P < 0.01$) as concentration of SBH increased, with steers fed 0% SBH being most efficient. A 3.9% decrease in G:F was observed from 12.5 to 25% SBH, and a 8.2% decrease in feed efficiency was noted when comparing 25 and 37.5% SBH. However, feed efficiency tended ($P = 0.12$) to increase quadratically as SBH concentration increased in Exp. 2. Steers fed 12.5% SBH were 2.3% more efficient than 0% SBH, this number slightly decreasing at the 25% concentration; however, numerically, steers fed 25% SBH were still 1.8% more efficient than those fed 0% SBH. A 3.4% decrease in feed efficiency was also observed between 25 and 37.5% SBH. Comparable results were observed by Bunyecha (2005) when they replaced corn with SBH (0, 25, 50, and 75% DM basis) in receiving diets and observed no difference in G:F at SBH inclusion concentration of 0, 25, or 75%, respectively.

In Exp. 1, HCW decreased linearly ($P < 0.01$) as inclusion of SBH in the diet increased (Table 3), with steers fed 0% SBH having carcasses that were 24 kg heavier than those fed 37.5% SBH. Similarly, HCW tended ($P = 0.12$) to decrease linearly as SBH concentration increased in Exp. 2 (Table 4). The response in HCW is attributed to the fact that increasing SBH concentration decreased ADG; therefore, HCW were lighter as SBH concentration increased. Marbling score tended ($P = 0.07$) to decrease linearly for Exp. 1 as SBH concentration increased, whereas no differences ($P \geq 0.57$) were observed in Exp. 2. Concentration of SBH had no effect on LM area ($P \geq 0.31$) in Exp. 1 or Exp. 2 ($P \geq 0.35$). Fat thickness was not different in Exp. 1 ($P \geq 0.78$); however, increasing concentrations of SBH in Exp. 2 resulted in a linear decrease ($P = 0.04$) in 12th rib fat thickness from 1.52 to 1.24 cm for SBH concentration of 0 and 37.5%, respectively. Calculated YG decreased linearly ($P < 0.01$) in Exp. 1 and tended ($P = 0.06$) to linearly decrease as SBH concentration increased in Exp. 2.

The calculated energy value (% of DRC) of SBH decreased linearly ($P < 0.01$) as SBH concentration increased in Exp. 1 (Table 3). The greatest (91%) calculated relative energy value was observed when feeding 12.5% SBH and the lowest (79%) was observed when feeding 37.5% SBH in finishing diets. The greatest calculated feeding value (69.6%) was when SBH were included in the diet at 12.5 and 25% DM, respectively. When dietary concentration of SBH was 37.5%, the feeding value of SBH decreased to 59.5%.

Table 4. The effects of soybean hull (SBH) inclusion on finishing cattle performance and carcass characteristics when fed with wet distillers grains plus solubles (Exp. 2)

	SBH inclusion,[1] % of diet DM					*P*-value	
Item	0	12.5	25	37.5	SEM	Linear[2]	Quadratic[3]
Performance							
Initial BW, kg	359	359	360	360	0.45	0.20	0.64
Final BW,[4] kg	601	611	601	591	5.9	0.12	0.13
DMI, kg/d	10.3	10.5	10.0	10.0	0.2	0.18	0.57
ADG, kg	1.76	1.83	1.75	1.67	0.04	0.09	0.12
G:F, kg/kg	0.171	0.175	0.174	0.168	0.003	0.45	0.12
Energy value,[5] %		106	107	99	6	0.23	0.49
Feeding value,[6] %		118.7	107.0	95.3			
Carcass characteristics							
HCW, kg	379	385	378	372	3.6	0.12	0.13
Marbling[7]	580	573	573	565	18	0.57	0.99
LM area, cm^2	82.84	83.35	83.74	84.90	1.55	0.35	0.83
12th rib fat, cm	1.52	1.35	1.32	1.24	0.10	0.04	0.61
Calculated YG[8]	3.58	3.43	3.33	3.19	0.13	0.06	0.98

[1]Dietary treatment concentrations of SBH.

[2]*P*-value for the linear response to SBH inclusion.

[3]*P*-value for the quadratic response to SBH inclusion.

[4]Calculated from carcass weight, adjusted to 63% common DP.

[5]Percentage relative to corn, calculated from percent TDN of SBH, divided by percent TDN of a dry-rolled corn:high-moisture corn blend (91.5%).

[6]Percentage of corn feeding value calculated as percent difference in G:F from control divided by inclusion rate.

[7]Marbling score: 400 = Slight, 500 = Small, 600 = Modest, and so on.

[8]YG = 2.50 + (6.35 × fat thickness, cm) + (0.2 × KPH, %) + (0.0017 × HCW, kg) − (2.06 × LM area, cm^2).

Four steers were removed or died due to bloat in Exp. 2. The cause of these cattle experiencing bloat in Exp. 2 is unclear because bloat was experienced with steers fed 0, 12.5, and 37.5% SBH. However, previous research has shown that feeding SBH may increase the occurrence of bloat (Shriver et al., 2000; Steele et al., 2001). Increasing SBH concentration had no effect ($P \geq 0.23$) on the calculated energy value of SBH relative to corn in Exp. 2 (Table 4). When feeding SBH at 12.5% DM, the feeding value relative to corn was greatest (118.7%). Intermediate (107.0%) feeding value was observed when SBH concentration was 25% of DM. When SBH was included in the diet at 37.5% DM, lowest (95.3%) feeding value was calculated.

The NRC (1996) reported the TDN of SBH to be 80%, which is 89% of corn (90% TDN). Our findings would suggest the energy value to be 79 to 107% that of corn, depending on the concentration of SBH in the diet. In the current studies, the feeding value of SBH was greater than that reported by Ludden et al. (1995). The main differences between these experiments is inclusion (Exp. 1 and Exp. 2) of distillers grains plus solubles or not (Ludden et al., 1995). One plausible explanation for greater energy values observed from cattle performance in Exp. 1 and Exp. 2 with distillers grains plus solubles would be positive associate effects of adding fibrous SBH in diets already containing digestible fiber from distillers grains plus solubles. A direct comparison of SBH energy value observed from performance in diets with or without other high-energy, fibrous by-products is warranted. The calculated energy value of SBH relative to corn decreased as concentration of SBH increased, and this was observed in both experiments. However, the major differences observed between Exp. 1 and 2 for the feeding and energy value of SBH is unclear. Possible differences could be partially attributed to the location (feeding or management) of the study, cattle type (calf fed vs. yearling steers), the form of SBH (pelleted vs. ground) used in the diet, or the type and inclusion level of distillers grains used. Previous work of Bremer (2010) reported that when including distillers grains at 10 to 40% of diet, the feeding values of distillers grains relative to corn were 150 to 130 and 128 to 117 (DM basis) for WDGS and MDGS, respectively. Similar to results in Exp. 1 and Exp. 2, these feeding values reported by Bremer et al. (2011) decreased as inclusion increased. In Exp. 1, MDGS were included in the diet at 25% DM, and Exp. 2, WDGS at 40% DM was included. Collectively, feedlot location, cattle type, and energy value of distillers grains could be all contributing to the animal performance differences observed.

IMPLICATIONS

The energy value of soybean hulls in finishing diets with WDGS is estimated to be 99 to 106% of that of corn when included in the diet at concentrations of 12.5 to 37.5%. In diets with MDGS, the energy value was poorer, 79 to 91% that of corn. The use of soybean hulls in finishing diets at concentrations greater than 12.5% DM resulted in a decrease in steer growth performance. However, when soybean hulls are included in the diet at 12.5% DM, along with WDGS, steer growth performance was greater. Evaluating the price of soybean hulls relative to corn and the relative energy value is critical for economics and optimizing use.

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