Feeding value of dried shredded sugarbeets as a partial replacement for steam-flaked corn in finishing diets for feedlot cattle

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ABSTRACT: Two experiments were conducted to evaluate the comparative feeding value of dried shredded sugarbeets (DSSB; 0, 20, and 40% of diet DM) as a replacement for steam-flaked corn (SFC) in finishing diets for feedlot cattle. In Exp. 1, 60 calf-fed Holstein steers (476 ± 6.3 kg) were used in a 97-d finishing trial. Substitution of SFC with DSSB did not affect ADG or DMI (P > 0.20). Increasing DSSB decreased gain efficiency (ADG:DMI; linear effect, P = 0.04) and dietary NE (linear effect, P = 0.03). Given that SFC has a NEₘ value of 2.38 Mcal/kg, the replacement NEₘ and NEₘ values for DSSB were 1.94 and 1.29 Mcal/kg, respectively. There were no treatment effects (P > 0.20) on carcass characteristics. In Exp. 2, 6 cannulated Holstein steers (205 kg) were used in a replicated 3 x 3 Latin square design to evaluate treatment effects on digestion. Ruminal digestion of starch, NDF, and feed N were not affected (P > 0.10) by DSSB, although ruminal OM digestion tended to increase (linear effect, P < 0.08). Replacing SFC with DSSB decreased flow of starch to the small intestine, but it increased flow of microbial N (linear effect, P = 0.05). There were no treatment effects (P > 0.14) on postruminal digestion of OM, NDF, starch, or feed N or total tract digestion of OM, starch, and N. Substitution of DSSB increased (linear effect, P = 0.05) total tract NDF digestion and decreased (linear effect, P = 0.05) dietary DE (Mcal/kg). Given that SFC has a DE value of 4.19 Mcal/kg, the replacement DE value of DSSB was 3.68 Mcal/kg. There were no treatment effects (P > 0.12) on ruminal pH or total VFA; however, DSSB decreased propionate (linear effect, P = 0.05) and increased acetate (linear effect, P = 0.07), butyrate (linear effect, P = 0.05), valerate (linear effect, P = 0.04), and estimated methane production (linear effect, P = 0.05). We concluded that DSSB may replace SFC in finishing diets at levels of up to 40% without detrimental effects on ADG and carcass characteristics. The NE value of DSSB is 82% that of SFC (DM basis). Partial replacement of SFC with DSSB alters ruminal VFA patterns, increasing estimated methane energy loss and slightly decreasing the efficiency of DE utilization.

Key words: cattle, digestion, performance, sugarbeet

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INTRODUCTION

Commercial sugarbeet yields range between 50 and 100 t clean beets/ha, with sugar concentrations of 17 to 18% on fresh weight (8 to 18 t sugar/ha; Milford, 2006). For 2010, beet yields in the U.S. averaged 62.2 t/ha. However, in the Imperial Valley (predominant cattle feeding region for the state of California), clean beet yields averaged 98.8 t/ha (USDA, 2010); 9 Imperial Valley beet growers topped the 2004 world record (148 t clean beets/ha), setting the new record at 156 t clean beets/ha (Lilleboe, 2010). With an average DM content of 23% (Milford, 2006), clean beet DM yields in the Imperial Valley averaged 22.7 t/ha, 277% the 2010 average DM yield for corn grain (8.2 t corn gain DM/ha; USDA, 2011b). For the year 2010, beet growers were paid an average of $52.80/t ($48.00/short ton; USDA, 2011a). Assuming an additional cost of $10.00/t for shredding and sun-drying the beets, the cost of shredded, dried beets would be $239.59/dry ton.
The present local cost of corn grain is $403.55/dry ton ($311.80/short t, 85% DM; Feedstuffs, 2011). On this current basis, sugarbeets show great potential as a reduced cost high-energy alternative to conventional grain in growing-finishing diet formulations for feedlot cattle.

Very little research has been reported on the comparative feeding value of sugarbeets for feedlot cattle (CABI, 2011). Kosar et al. (1971) approximated that 4 kg fresh sugarbeet could replace 1 kg barley-meal in diets for fattening bulls. On the basis of current tabular values for barley grain (NEm and NEg of 2.06 and 1.40 Mcal/kg, respectively; NRC, 1996) and assuming that the DM content of sugarbeets fed was 23%, the corresponding NEm and NEg values for sugarbeets in their study equates to a 1.97 and 1.32 Mcal/kg, respectively.

The objective of present study was to evaluate the comparative feeding value of dried shredded sugarbeets (DSSB) as a replacement for steam-flaked corn (SFC) in finishing diets for feedlot cattle.

**MATERIALS AND METHODS**

All procedures involving animal care and management were in accordance with and approved by the University of California, Davis, Animal Use and Care Committee.

**Experiment 1**

**Animals and Diets.** Sixty calf-fed Holstein steers (476 ± 6.3 kg) were used in a 97-d experiment to evaluate the comparative feeding value of DSSB, with respect to feedlot growth-performance, dietary NE, and carcass characteristics. Eight days before initiation of the experiment, calves were individually weighed, implanted with Revalor-S (Intervet/Schering-Plough Animal Health, Millsboro, DE), grouped by BW into 5 blocks, and randomly assigned within BW blocks to 15 pens (4 steers per pen). Pens were 75 m², with 27 m² of overhead shade, automatic waterers, and 4.3-m fence-line feed bunks. During this 8-d preliminary period, all steers received the same finishing diet (control diet, Table 1). Dried shredded sugarbeet was prepared as follows: 1) freshly harvested beet tubers (not cleaned or washed) were shredded in a single pass through a forage chopper (New Holland model 33 flail chopper); 2) shredded beets were then spread on a concrete pad to a depth of roughly 5 cm; 3) material was turned twice daily until air-dry (3 d). Three inclusion rates of DSSB (0, 20, and 40%, DM basis) were evaluated. Dried shredded sugarbeets was substituted for SFC (DM basis) in the basal diet. Treatments were randomly assigned to pens within BW blocks. Composition of experimental diets is shown in Table 1. Steers were allowed ad libitum access to their experimental diets. Fresh feed was provided twice daily.

**Estimation of Dietary NE.** Energy gain (EG) was calculated with the equation \( EG = ADG^{1.097} \times 0.0557 \times W^{0.75} \), where EG is the daily energy deposited (Mcal/d), and W is the mean shrunk BW (kg; NRC, 1984). Maintenance energy (EM) was calculated with the equation \( EM = 0.084 W^{0.75} \) (NRC, 1984). Dietary NEg was derived from NEm with the equation \( NEg = 0.883 NE_m - 0.42 \) (derived from NRC, 1996; \( R^2 = 0.9997 \)). Dry matter intake is related to energy requirements and dietary NEm according to the equation \( DMI = EG \div (0.883 NE_m - 0.42) \) and can be resolved for estima-
tion of dietary NE by means of the quadratic formula
\[ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \]
where \( x = \text{NE} \), \( a = -0.42 \), \( b = 0.883 \), \( c = -0.883 \), and \( DMI \) (Zinn and Shen, 1998).

**Carcass Data.** Hot carcass weights were obtained at time of slaughter. After carcasses were chilled for 48 h, the following measurements were obtained: LM area (cm²) by direct grid reading of the LM at the 12th rib; subcutaneous fat (cm) over the LM at the 12th rib taken at a location 3/4 the lateral length from the chine bone end (adjusted by eye for unusual fat distribution); KPH as a percentage of HCW; marbling score (USDA, 1997; e.g., using 3.0 as minimum slight, 4.0 as minimum small, 5.0 as minimum modest, 6.0 as minimum moderate); and estimated retail yield of boneless, closely trimmed retail cuts from the round, loin, rib and chuck (% of HCW; Murphey et al., 1960) = 52.56 – 1.95 × subcutaneous fat – 1.06 × KPH + 0.106 × LM area – 0.018 × HCW.

**Experiment 2**

**Animals and Sampling.** Six Holstein steers (205 kg) with cannulas in the rumen (3.8-cm internal diameter) and proximal duodenum (Zinn and Plascencia, 1993) were used in a replicated 3 × 3 Latin square experiment to study treatment effects on characteristics of digestion. Treatments were the same as those used in Exp. 1 (Table 1), with the inclusion of 0.40% chromic oxide as a digesta marker. Steers were maintained in individual pens (5.6 m²) with automatic waterers. Diets were fed at 0800 and 2000 h daily. To avoid the complications of feed refusals, DMI was restricted to 4.6 kg/d (2.25% of BW daily). Experimental periods were 14 d, with 10 d for dietary treatment adjustment and 4 d for collection. During collection, duodenal and fecal samples were taken twice daily as follows: d 1, 0750 and 1350 h; d 2, 0900 and 1500 h; d 3, 1050 and 1650 h; and d 4, 1200 and 1800 h. Individual samples consisted of approximately 700 mL of duodenal chyme and 200 g (wt basis) of fecal material. Samples from each steer within each collection period were composited for analysis. During the final day of each collection period, ruminal samples were obtained from each steer via ruminal cannula 4 h after feeding. Ruminal fluid pH was determined on fresh samples. Samples were strained through 4 layers of cheesecloth. Two milliliters of freshly prepared 25% (wt/vol) meta-phosphoric acid was added to 8 mL of strained ruminal fluid. Samples were then centrifuged (17,000 × g for 10 min), and supernatant fluid was stored at −20°C for VFA analysis (gas chromatography; Zinn, 1988). Upon completion of the experiment, ruminal fluid was obtained via the ruminal cannula from all steers and composited for isolation of ruminal bacteria by differential centrifugation (Bergen et al., 1968).

**Sample Analysis and Calculations.** Samples were subjected to all or part of the following analysis: DM (oven drying at 105°C until no further weight loss), ash, ammonia N, crude fiber, Kjeldahl N (AOAC, 1984); NDF (Goering and Van Soest, 1970, with inclusion of amylose, adjusted for insoluble ash); chromic oxide (Hill and Anderson, 1958); purines (Zinn and Owens, 1986); and starch (Zinn, 1990). Digesta flow to the small intestine and fecal excretion were based on marker ration, using chromic oxide. Microbial OM and N leaving the abomasum were calculated using purines as a microbial marker (Zinn and Owens, 1986). Organic matter fermented in the rumen was considered equal to OM intake minus the difference between the amount of total OM reaching the duodenum and microbial OM reaching the duodenum. Feed N escape to the small intestine was considered equal to total N leaving the abomasum minus ammonia-N and microbial N and, thus, includes any endogenous additions. Methane production (mol/mol glucose equivalent fermented) was estimated on the basis of the theoretical fermentation balance for observed molar distribution of VFA (Wolin, 1960).

**Statistical Design and Analysis.** For calculating steer performance in Exp. 1, initial and final BW were reduced 4% to account for digestive tract fill. Final shrunken LW was adjusted for HCW by dividing HCW by the decimal fraction of the average dressing percentage (0.627). Pens were used as experimental units. The experimental data were analyzed as a randomized block design experiment. The effects of sugar beet inclusion on characteristics of digestion in cattle (Exp. 2) were analyzed as a replicated 3 × 3 Latin square, according to the following statistical model: Yijkl = m + Bi + Aj(i) + Pk + Tl + Eijkl, where B is block, A is steer within block, Pk is period, Tl is treatment, and Eijkl is residual error. Treatments effects were tested by means of orthogonal polynomials (Hicks, 1973). Analysis was performed using Statistix8 (Analytical Software, Tallahassee, FL).

**RESULTS AND DISCUSSION**

Treatment effects on growth performance and estimated NE value of the diet (Exp. 1) are shown in Table 2. Substitution of SFC with DSSB did not affect ADG or DMI (P > 0.20). Across treatments, daily energy intake (33.5 Mcal ME) and corresponding ADG (1.44 kg) were remarkably high for calf-fed Holstein steers during the latter finishing phase. For example, Hussein and Berger (1995) and Salinas-Chavira et al. (2009) reported ADG of 0.76 and 1.15 kg, respectively, for calf-fed Holstein steers during the corresponding late finishing phase. This distinction in ADG is emphasized to illustrate that DSSB substitution did not negatively affect or limit diet acceptability (energy intake), even under the condition...
of greater-than-average growth performance potential. Furthermore, and notwithstanding the increased sugar content of DSSB, its substitution into the diet at inclusions as great as 40% of DM did not provoke visually apparent digestive dysfunctions (clinical signs of acidosis, founder, or bloat).

Increasing DSSB decreased BW gain efficiency (ADG:DMI; linear effect, $P = 0.04$) and dietary NE (linear effect, $P = 0.03$). Observed dietary NE was slightly greater (108%) than expected (Table 1; NRC, 1984) for steers receiving the control diet. By adjusting estimated dietary NE values for this differential and regressing these standardized values on DSSB as a percentage of the sum of DSSB plus SFC in the respective diets (PDSSB), the following relationship was obtained: dietary NE$_{m}$ = 2.13 − 0.00258 PDSSB ($R^2 = 0.93$). The corresponding NE values for DSSB can be determined by the replacement technique (Zinn et al., 1997). Given that SFC has a NE$_{m}$ value of 2.38 Mcal/kg (NRC, 1984) and 59% of the diet is DSSB plus SFC, the replacement NE$_{m}$ value of DSSB would be 1.94 Mcal/kg (2.38 − 0.258 ÷ 0.59). Proportionate NE$_{g}$ value for DSSB is 1.29 Mcal/kg.

Tabular NE values for sugarbeets are not reported (NRC, 1984, 1996). However, replacement NE$_{m}$ and NE$_{g}$ values for DSSB based on growth performance correspond with tabular values for fresh mangel beet roots (1.94 and 1.30 Mcal/kg, respectively; NRC, 1984). Mangels are larger beets closely related to the sugarbeet.

There were no treatment effects ($P > 0.20$) on carcass characteristics (Table 3). Percentage of cattle grading choice or greater averaged 80, 78, and 84% for 0, 20, and 40% DSSB substitution, respectively. Likewise, Modjanov and Sul’ga (1965) did not observe effects of sugarbeet feeding on carcass yield or meat quality.

Dietary treatment effects on characteristics of ruminal and total tract digestion (Exp. 2) are shown in Table 4. Ruminal digestibility of OM tended to increase (linear effect, $P < 0.08$) with increased DSSB in diet. Ruminal digestion of starch, NDF, and feed N were not affected ($P > 0.10$) by DSSB inclusion. Replacing SFC with DSSB decreased flow of starch to the small intestine but increased flow of microbial N (linear effect, $P = 0.05$). There were no treatment effects ($P > 0.15$) on post-ruminal digestion of OM, NDF, starch, or feed N. There were no treatment effects ($P > 0.14$) on total tract digestion of OM, starch, or feed N. Dried shredded sugarbeets substitution increased (linear effect, $P = 0.05$) total tract NDF digestion and decreased (linear effect, $P = 0.05$) dietary DE (Mcal/kg). As in Exp. 1, DE value of DSSB vs. SFC can be determined from changes in dietary DE with inclusion of DSSB substitution. Because tabular DE values are based on measures at a maintenance level of intake, it is necessary first to adjust the DE values in Table 4 for this differential. The expected DE value of the diet containing 0% DSSB is 3.87 Mcal/kg (Table 1; NRC, 1984). Accordingly, the observed DE values in Table 4 may be standardized by dividing by 0.89. By regressing these standardized values on DSSB as a percentage of the sum of DSSB plus SFC in the respective diets (PDSSB), the following relationship is obtained: $DE = 3.86 − 0.00298 PDSSB$ ($R^2 = 0.996$).

Given that SFC has a DE value of 4.19 Mcal/kg (NRC, 1984) and 59% of the diet is DSSB plus SFC, the replacement DE value of DSSB would be 3.68 Mcal/kg (4.19 − 0.298/0.59). This value is 3.9% greater than expected on the basis of observed NE$_{m}$ (Exp. 1; where $DE = 0.80671 + 1.41012$ NE$_{m}$; derived from NRC 1996, $R^2 = 0.998$) and 6.7% greater than expected on the basis of nutrient composition (3.45 Mcal/kg; Table 1). The basis for this effect may be related to lower energetic efficiency of ruminal vs. intestinal OM digestion. Armstrong et al. (1960) observed that the efficiency of energy utilization from glucose infused into the rumen was 69 to 76% of that of glucose infused into the small intestine. Likewise,
Owens et al. (1986) observed that the efficiency of energy utilization from starch digested in the rumen was 70% that of starch digested in the small intestine.

Treatment effects on characteristics of ruminal fermentation are shown in Table 5. There were no treatment effects (P > 0.12) on ruminal pH, isobutyrate, isovalerate, or total VFA molar concentrations. However, DSSB decreased ruminal molar proportion of propionate (linear effect, P = 0.05), and it increased molar proportions of acetate (linear effect, P = 0.07), butyrate (linear effect, P = 0.05), and valerate (linear effect, P = 0.04) and estimated methane production (linear effect, P = 0.05). Increased methane energy losses with DSSB supplementation may account for the small discrepancy between observed NE based on growth-performance (Exp. 1) and expected NE based on measures of DE (Exp. 2).

Conclusions

Dried shredded sugarbeets may replace SFC in finishing diets at inclusions of up to 40% without having detrimental effects on diet acceptability, daily BW gain, and carcass characteristics. Dried shredded sugarbeets have 82% the NE value of SFC (DM basis). Partial replacement of SFC with DSSB alters ruminal VFA patterns, increasing estimated methane energy loss and slightly decreasing the efficiency of DE utilization.

LITERATURE CITED

Dried shredded sugarbeets feedlot cattle


