

# The influence of supplementation with haylage, haylage plus soybean meal or haylage plus corn dried distillers' grains with solubles on the performance of wintering pregnant beef cows fed wheat straw

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Wood, K. M., Mandell, I. B. and Swanson, K. C. 2010. **The influence of supplementation with haylage, haylage plus soybean meal or haylage plus corn dried distillers' grains with solubles on the performance of wintering pregnant beef cows fed wheat straw.** *Can. J. Anim. Sci.* **90**: 547–553. Fourteen pens containing a total of 53 individually fed, multiparous, pregnant, crossbred beef cows were used to investigate feeding of free-choice haylage or supplementation programs for cows fed wheat straw. Dietary treatments for the 112-d feeding period were: free choice haylage (pens = 2, cows = 7; 100% Haylage), haylage offered at 0.7% body weight (BW) plus free choice straw (pens = 3, cows = 11; 0.7% Haylage), haylage offered at 1% of BW plus free choice straw (pens = 3, cows = 12; 1% Haylage), haylage offered at 0.5% BW plus soybean meal and free choice straw (pens = 3, cows = 12; Haylage+SBM), and haylage offered at 0.5% BW plus corn dried distillers' grains plus solubles and free choice access to straw [pens = 3, cows = 11; Haylage+dried distillers' grains with solubles (DDGS)]. The non-straw component of Haylage+SBM and Haylage+DDGS was formulated to provide equal amounts of N (relative to BW) to that of 1% Haylage. Total dry matter intake (DMI) was greater ( $P \leq 0.01$ ) in cows receiving 100% Haylage vs. other treatments and 1% Haylage, Haylage+SBM, and Haylage+DDGS vs. 0.7% Haylage. Straw DMI was greater ( $P < 0.001$ ) in cows receiving Haylage+SBM and Haylage+DDGS vs. 1% Haylage. Average daily gain was greater ( $P \leq 0.002$ ) in cows receiving 100% Haylage vs. other treatments, 1% Haylage, Haylage+SBM, and Haylage+DDGS vs. 0.7% Haylage, and Haylage+SBM and Haylage+DDGS vs. 1% Haylage. These data indicate that feeding wheat straw supplemented with haylage or haylage plus SBM or DDGS may be an acceptable alternative to free-choice haylage to minimize winter feed costs and that supplementation with Haylage plus SBM or Haylage plus DDGS results in increased straw DMI and ADG when compared to supplementation with haylage alone.

**Key words:** Beef cattle, straw, winter feeding, supplementation

Wood, K. M., Mandell, I. B. et Swanson, K. C. 2010. **Effets d'un supplément d'ensilage de mi-fané, d'ensilage de mi-fané enrichi de tourteau de soja ou d'ensilage de mi-fané enrichi de drêches sèches de maïs et d'extraits solubles de distillerie sur le rendement des vaches de boucherie gravides nourries de paille de blé durant l'hiver.** *Can. J. Anim. Sci.* **90**: 547–553. Les auteurs ont recouru à 53 vaches de boucherie hybrides, multipares et gravides, réparties dans 14 enclos et nourries individuellement, pour étudier l'incidence du mi-fané servi à satiété ou de l'ensilage enrichi sur les vaches engraisées avec de la paille de blé. Les régimes durant la période d'hivernage de 112 jours étaient les suivants : ensilage de mi-fané servi à satiété (enclos = 2, vaches = 7; 100% de mi-fané), ensilage de mi-fané servi à raison de 0,7% du poids corporel plus paille à satiété (enclos = 3, vaches = 11; 0,7% de mi-fané), ensilage de mi-fané servi à raison de 1% du poids corporel plus paille à satiété (enclos = 3, vaches = 12; 1% de mi-fané), ensilage de mi-fané servi à raison de 0,5% du poids corporel plus tourteau de soja et paille à satiété (enclos = 3, vaches = 12; mi-fané+TS), et ensilage de mi-fané servi à raison de 0,5% du poids corporel enrichi de drêches sèches de maïs et d'extraits solubles de distillerie et paille de blé à satiété (enclos = 3, vaches = 11; mi-fané+DSESD). La partie non-paille des rations mi-fané+TS et mi-fané+DSESD était formulée pour fournir une quantité de N identique (par rapport au poids corporel) à celle de la ration 1% de mi-fané. Les vaches nourries uniquement avec du mi-fané ont ingéré plus de matière sèche ( $P \leq 0,01$ ) que celles recevant les autres rations; il en va autant pour les vaches engraisées avec 1% de mi-fané, du mi-fané+TS et du mi-fané\_DSESD, comparativement à celles recevant 0,7% de mi-fané. Les vaches recevant du mi-fané+TS ou du mi-fané+DSESD ont ingéré plus de matière sèche de paille ( $P < 0,001$ ) que celles nourries avec 1% de mi-fané. Les vaches engraisées uniquement avec du mi-fané ont enregistré un gain quotidien moyen (GQM) supérieur ( $P \leq 0,002$ ) à celui des autres vaches; le GQM des vaches recevant 1% de mi-fané, du mi-fané+TS ou du mi-fané+DSESD était plus élevé que celui des animaux nourris avec 0,7% de mi-fané; et celles engraisées avec du mi-fané +TS ou du mi-fané+DSESD avaient un meilleur GQM que celles nourries avec 1% de mi-fané. Ces données indiquent que la paille de blé accompagnée de mi-fané

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**Abbreviations:** ADF, acid detergent fibre; BF, backfat; BCS, body condition score; BW, body weight; CP, crude protein; DDGS, dried distillers' grains with soluble; DM, dry matter; DMI, dry matter intake; NE<sub>m</sub>, net energy for maintenance; PUN, plasma urea nitrogen

ou de mi-fané enrichi de TS ou de DSESD pourrait constituer une solution de rechange acceptable au mi-fané servi à satiété pour minimiser les coûts d'hivernage, le supplément de mi-fané enrichi de TS ou de DSESD contribuant à accroître l'ingestion de matière sèche de la paille et le gain quotidien moyen comparativement à un supplément uniquement constitué de mi-fané.

**Mots clés:** Bovins de boucherie, paille, ration d'hiver, supplément

The winter feeding of beef cows is one of the greatest costs of production in the cow/calf industry. Kaliel and Kotowich (2002) reported that winter feeding of beef cows represents 60–65% of the total cost of production in a Canadian cow/calf operation. When winter grazing is not available, there may be opportunities to reduce winter feeding costs by utilizing lower cost feedstuffs. Crop residues and straws in particular, can be a readily available and low cost feedstuff for a winter cow ration.

Crop residues may provide up to 50 to 60% of dry matter intake (DMI) needed to maintain the pregnant beef cow over winter (McCartney et al. 2006); however, an additional nutrient source is needed to meet the requirements for energy and crude protein (CP), prevent rumen impaction, maintain DMI, improve digestibility and increase performance (Pritchard and Males 1982; Wiedmeier et al. 1983; Pritchard and Males 1985; Bohnert et al. 2002; Tellier et al. 2004). The impact of nutrition on the pre-partum performance of the cow must be considered in any winter feeding program, since poor pre-partum nutrition can negatively impact the growth and development of the conceptus [National Research Council (NRC) 1996].

Wheat straw is an effective feedstuff for use in wintering beef cows, particularly in western Canada (McCartney et al. 2006). Since wheat straw alone is low in CP and high in neutral detergent fibre and acid detergent fiber (ADF), digestibility and voluntary intake can be relatively low (Males 1987). High-quality forages may supply additional protein and energy that are required by the animal without the use of additional higher priced supplements.

Some of the research into the use of straw in beef cow rations has focused on chemical additives and treatments of straw to increase protein content and improve nutritive value and digestibility by processes such as ammoniation (Males 1987). A great deal is understood about the need to provide an additional nitrogen source to cattle consuming straw (Preston and Leng 1984); however, little research has been conducted investigating the use of high-quality forages or forage and supplement blends as supplemental N and energy sources for free-choice wheat straw-based rations in a winter feeding system on the performance of pregnant beef cows.

The objectives of this experiment were to examine the effects of supplementation programs using haylage, or haylage plus soybean meal or corn dried distillers' grains plus solubles in dry pregnant beef cows fed wheat straw on performance over the fall/winter months leading up to parturition, and to compare the performance of the

cows on these supplementation regimes with a free choice haylage feeding system.

## MATERIALS AND METHODS

### Animals and Dietary Treatments

This experiment followed the recommendations of the Canadian Council on Animal Care (1993) and met the approval of the University of Guelph Animal Care Committee. Fifty-three individually fed multiparous crossbred cows [ $160 \pm 13.7$  (SD) d pregnant at the beginning of the experimental period], of primarily Angus and Simmental breeding were used and housed at the New Liskeard Agricultural Research Station. Three to four cows were randomly assigned to 1 of 14 pens and one of five treatments randomly assigned to pens in a completely randomized design. Cows were fed treatment diets for 112 d. The five dietary treatments were: free choice haylage (pens = 2, cows = 7; 100% Haylage), haylage offered initially at 0.5% and later at 0.75% with free choice access to wheat straw (pens = 3, cows = 11; 0.7% Haylage), haylage offered at 1% of body weight (BW) with free choice access to wheat straw (pens = 3, cows = 12; 1% Haylage), haylage offered at 0.5% of BW plus soybean meal with free choice access to wheat straw (pens = 3, cows = 12; Haylage+SBM), and haylage offered at 0.5% of BW plus dried corn distiller's grains plus solubles with free choice access to wheat straw [pens = 3, cows = 11; Haylage+dried distillers' grains with solubles (DDGS)]. The inclusion rate of the soybean meal and distillers' grains plus solubles (on average 1.3 and 2.3 kg d<sup>-1</sup>, respectively) was such that the non-straw component of the rations would be isonitrogenous to the non-straw component of 1% Haylage (Table 1). Haylage was stored in a plastic silage bag and was composed of >60% alfalfa, with the remainder consisting of a blend of orchardgrass and timothy. A commercially available beef cow vitamin and mineral premix containing 15% calcium, 12% phosphorus, 5% sodium, 4% magnesium, 600 kIU kg<sup>-1</sup> vitamin A, 50 kIU kg<sup>-1</sup> vitamin D, 1000 IU kg<sup>-1</sup> vitamin E, and 30 mg kg<sup>-1</sup> selenium was top dressed at a rate of 100 g d<sup>-1</sup>. The average nutrient compositions of each of the dietary components are presented in Table 1. Cows were individually fed using a Calan Gate system (American Calan, Inc., Northwood, NH) for 16 wk (October through January) over the late fall and winter leading up to parturition. Cows were offered the specified amount of haylage and supplement (if applicable) in the morning, allowed to completely consume it, and then offered free choice access to straw for the

**Table 1. The average nutrient composition of diet components (DM basis)**

Item	Wheat straw	Haylage <sup>z</sup>	Soybean meal	Corn dried distillers' grains + solubles
DM <sup>y</sup> (%)	87.7	37.1	91.4	93.3
CP <sup>x</sup> (% DM)	4.4	17.1	51.4	30.1
ADF <sup>w</sup> (% DM)	55.8	40.9	11.1	12.9
NDF <sup>v</sup> (% DM)	81.8	49.0	14.4	35.2
TDN <sup>u</sup> (%)	44.3	55.4	85.7	84.2
NEm <sup>t</sup> (Mcal kg <sup>-1</sup> )	0.81	1.35	2.00	1.80
NEg <sup>t</sup> (Mcal kg <sup>-1</sup> )	0.09	0.63	1.28	1.07

<sup>z</sup>Haylage consisted of >60% alfalfa and remainder mixed grasses.

<sup>y</sup>Dry matter.

<sup>x</sup>Crude protein.

<sup>w</sup>Acid detergent fibre.

<sup>v</sup>Neutral detergent fibre.

<sup>u</sup>Total digestible nutrients, calculated according to Weiss et al. (1992).

<sup>t</sup>Calculated according to NRC (1996).

remainder of the day (offered in AM after supplement consumed and again in PM). Straw was offered at approximately 125% of the previous day's straw consumption. Intakes were recorded on a daily basis. Average temperature during the experiment was  $-0.8^{\circ}\text{C}$  (National Climate Data and Information Archive 2009).

### Sample Collection and Analysis

At the start and end of trial cows were weighed twice, 24 h apart, before feeding in the AM. Body weights and body condition scores (BCS) were taken every 14 d before feeding in the AM, and BWs were used to adjust the amounts of haylage and supplements provided to cows fed rations containing wheat straw. Pregnancy-adjusted ADG for individual cows was calculated by subtraction of predicted fetal, gravid uterus, and membrane weights using the models described by Silvey and Haydock (1978). Body condition score measurements were conducted by the same individual using a 1 to 5 scale, where 1 was considered emaciated and 5 was obese (Ontario Farm Animal Council 2009). Ultrasound measurements were obtained to determine backfat (BF) depth (between the 12th and 13th ribs) and intramuscular fat content (IMF) on day 1 and day 112. Blood samples were obtained via jugular venipuncture on day 1 and day 112 for later analysis of plasma glucose and urea nitrogen. At parturition, birth weight of the calf was obtained within 24 h of birth.

Weekly feed samples were collected and frozen at  $-20^{\circ}\text{C}$  for future analysis. Samples were later dried at  $55^{\circ}\text{C}$  for 96 h to determine dry matter (DM) and then ground to pass through a 1-mm screen. All feed analysis was conducted at the Agri-Food Laboratories Inc. (Guelph, ON). Dry matter analysis was done in accordance with the Association of Official Analytical Chemists guidelines (AOAC 1990, Method 930.15). Feed N concentration was determined using a Leco N analyzer (Leco Corporation, St. Joseph, MI) and CP calculated by multiplying 6.25 by percent feed nitrogen.

Neutral detergent fibre and ADF were determined using the methods of Robertson and Van Soest (1981) using an Ankom fibre analyzer (Ankom Technology Corp., Fairport, NY).

Blood samples were centrifuged at  $3000 \times g$  for 20 min and plasma was separated and then frozen at  $-20^{\circ}\text{C}$  until analyzed. Plasma urea N (PUN; Sampson et al. 1980) and glucose (Trinder 1969) concentrations were analyzed by spectrophotometry using the PowerWave XS microplate spectrophotometer (BioTek Instruments Inc., Winooski, VT) and commercially available kits from Teco Diagnostics (Anaheim, CA).

### Statistical Analysis

Cows were randomly assigned to 1 of 14 pens, and pen was then randomly assigned to one of five dietary treatments. Data were analyzed as a completely randomized design using PROC MIXED in SAS (SAS Institute, Inc. 2008). The model included the effect of parity as a covariate and dietary treatment. Pen within dietary treatment was specified as a repeated measures subject to allow individual cow covariate adjustment, while retaining pen as the experimental unit. The model for calf birth weight also included the effect of calf sex and sire as covariates. Contrast statements were used to compare between dietary treatment groups: Contrast 1 = 100% Haylage vs. 1% Haylage, Haylage + SBM, and Haylage + DDGS; Contrast 2 = 0.7% Haylage vs. 1% Haylage, Haylage + SBM, and Haylage + DDGS; Contrast 3 = 1% Haylage vs. Haylage + SBM and Haylage + DDGS; Contrast 4 = Haylage + SBM vs. Haylage + DDGS.  $P < 0.05$  was used to indicate significance.

### RESULTS AND DISCUSSION

On day 37, haylage intake was adjusted from 0.5 to 0.75% of BW (DM basis) for cows on 0.7% Haylage, (0.7% is the weighted average over the trial period) to alleviate future concerns regarding ruminal impaction, as one cow on this treatment showed signs of compaction and was removed from the experiment.

Total DMI was greater ( $P \leq 0.01$ ) in cows receiving 100% Haylage vs. other treatments and 1% Haylage, Haylage+SBM, and Haylage+DDGS vs. 0.7% Haylage, but did not differ between cows receiving 1% Haylage vs. Haylage+SBM and Haylage+DDGS or Haylage+SBM vs. Haylage+DDGS (Table 2). Total forage DMI was greater ( $P \leq 0.008$ ) in cows receiving 100% Haylage vs. other treatments and 1% Haylage vs. Haylage+SBM and Haylage+DDGS, but did not differ between cows receiving 0.7% Haylage vs. 1% Haylage, Haylage+SBM, and Haylage+DDGS or Haylage+SBM vs. Haylage+DDGS. Straw DMI was greater ( $P < 0.001$ ) in cows receiving Haylage+SBM and Haylage+DDGS vs. 1% Haylage, but did not differ between 0.7% Haylage vs. 1% Haylage, Haylage+SBM, and Haylage+DDGS or Haylage+SBM vs. Haylage+DDGS. Haylage and supplement DMI were consistent with the experimental design except for 0.7% Haylage, which required adjustment mid-trial as described above. Cows fed Haylage+DDGS consumed more supplement DMI than cows fed Haylage+SBM, because DDGS was lower in protein than the SBM supplements, so more DDGS was required than SBM in order to remain isonitrogenous with the 1% Haylage treatment.

Studies have indicated that supplemental CP (Church and Santos 1981; DelCurto et al. 1990) increases voluntary intake of straws and low-quality forage. Feed digestibility and physical barriers may be the major factors limiting voluntary straw intake. Increased straw intake in cows receiving Haylage+SBM or Haylage+DDGS vs. 1% Haylage could be due to differences in fibre concentration, energy concentration, or protein degradability between the different supplements, which could result in differences in rumen fill or digestibility. The increased fibre content of alfalfa haylage vs. alfalfa haylage plus soybean meal or corn distillers' grains plus solubles could have resulted in the observed decrease in straw intake because of a rumen fill

effect, which is thought to limit intake when lower-quality forages are fed (Mertens 1987). Typically, increasing energy concentration of supplements (especially with rapidly degradable carbohydrates) for ruminants fed low-quality forages results in decreased forage intake (Caton and Dhuvetter 1997). It is unlikely that differences in straw DMI were the result of increased energy concentration of the supplements because the supplements did not contain high concentrations of readily degradable carbohydrates. It is unclear if changes in ruminal protein degradability influenced straw DMI, as changes in ruminal protein degradability have resulted in inconsistent effects on forage intake in ruminants fed low-quality forage (Bohnert et al. 2002; Salisbury et al. 2004; Swanson et al. 2004).

Final BW was greater ( $P = 0.04$ ) in cows receiving 1% Haylage, Haylage+SBM, and Haylage+DDGS vs. 0.7% Haylage, but did not differ when comparing 100% Haylage vs. other treatments, 1% Haylage vs. Haylage+SBM and Haylage+DDGS, and Haylage+SBM vs. Haylage+DDGS (Table 3). Average daily gain was greater ( $P \leq 0.002$ ) in cows receiving 100% Haylage vs. other treatments, 1% Haylage, Haylage+SBM, and Haylage+DDGS vs. 0.7% Haylage, and Haylage+SBM and Haylage+DDGS vs. 1% Haylage and tended to be greater ( $P = 0.07$ ) in cows receiving Haylage+DDGS vs. Haylage+SBM. Pregnancy corrected ADG was greater ( $P \leq 0.02$ ) in cows receiving 1% Haylage, Haylage+SBM, and Haylage+DDGS vs. 0.7% Haylage and Haylage+SBM and Haylage+DDGS vs. 1% Haylage, tended to be greater ( $P = 0.07$ ) in cows receiving 100% Haylage vs. other treatments, and did not differ between cows receiving Haylage+SBM vs. Haylage+DDGS. Final BCS and change in BCS were greater ( $P \leq 0.02$ ) in cows receiving 100% Haylage vs. other treatments and 1% Haylage, Haylage+SBM, and Haylage+DDGS vs. 0.7% Haylage, but did not differ between cows receiving 1% Haylage vs. Haylage+SBM and Haylage+DDGS or Haylage+SBM vs.

**Table 2. Influence of feeding free choice haylage or supplementation of a wheat straw-based diet on average dry matter intakes for each dietary component**

Item	Dietary treatment <sup>2y</sup>						Contrast P <sup>x</sup>			
	100% Haylage	0.7% Haylage	1% Haylage	Haylage +SBM	Haylage +DDGS	SEM	1	2	3	4
Total DMI (kg d <sup>-1</sup> )	14.2	9.0	10.2	10.1	10.8	0.47	<0.001	0.01	0.62	0.16
Total forage DMI (kg d <sup>-1</sup> )	14.2	9.0	10.2	8.8	8.6	0.46	<0.001	0.61	0.008	0.68
Straw DMI (kg d <sup>-1</sup> )	–	4.4	3.1	5.1	4.9	0.25	–	0.81	<0.001	0.49
Haylage DMI (kg d <sup>-1</sup> )	14.2	4.6	7.1	3.7	3.7	–	–	–	–	–
Supplement DMI (kg d <sup>-1</sup> )	–	–	–	1.3	2.3	–	–	–	–	–

<sup>2y</sup>Values are least square means.

<sup>1</sup>100% Haylage = free choice haylage (pens = 2, cows = 7); 0.7% Haylage = haylage offered at 0.5% of BW for 36 d and 0.75% for remainder with free choice access to wheat straw (pens = 3, cows = 11); 1% Haylage = haylage offered at 1% of BW with free choice access to wheat straw (pens = 3, cows = 12); Haylage+SBM = haylage offered at 0.5% of BW plus soybean meal with free choice access to wheat straw (pens = 3, cows = 12); Haylage+DDGS = haylage offered at 0.5% of BW plus dried corn distillers grains plus solubles with free choice access to wheat straw (pens = 3, cows = 11).

<sup>x</sup>Contrast 1 = 100% Haylage vs. 1% Haylage, Haylage+SBM, and Haylage+DDGS; Contrast 2 = 0.7% Haylage vs. 1% Haylage, Haylage+SBM, and Haylage+DDGS; Contrast 3 = 1% Haylage vs. Haylage+SBM and Haylage+DDGS; Contrast 4 = Haylage+SBM vs. Haylage+DDGS.

**Table 3. Influence of feeding free choice haylage or supplementation of a wheat straw-based diet on final and changes in BW, BCS, ultrasound measures, and plasma metabolites, and calf birth weight**

Item	Dietary treatment <sup>2,3</sup>					SEM	Contrast P <sup>x</sup>			
	100% Haylage	0.7% Haylage	1% Haylage	Haylage +SBM	Haylage +DDGS		1	2	3	4
Final BW (kg)	782.5	671.6	714.4	750.1	756.8	30.9	0.26	0.04	0.22	0.85
ADG (kg d <sup>-1</sup> )	0.91	0.16	0.34	0.55	0.71	0.07	<0.001	<0.001	0.002	0.07
Pregnancy corrected ADG (kg d <sup>-1</sup> )	0.31	-0.35	-0.14	0.13	0.19	0.11	0.07	0.005	0.02	0.57
Final BCS <sup>w</sup>	3.5	2.7	3.1	3.2	3.3	0.10	0.02	0.002	0.12	0.52
Change in BCS	0.1	-0.6	-0.4	-0.3	-0.3	0.09	0.001	0.02	0.39	0.66
Final backfat (mm)	13.8	15.6	16.2	15.1	14.4	0.93	0.20	0.65	0.14	0.53
Change in backfat (mm)	-0.2	1.1	1.5	0.8	1.0	0.58	0.07	0.99	0.27	0.81
Final IMF <sup>v</sup> (%)	5.4	4.9	4.6	4.7	4.8	0.28	0.05	0.43	0.51	0.71
Change in IMF (%)	0.13	0.04	-0.2	-0.12	-0.15	0.21	0.25	0.34	0.77	0.90
Final PUN <sup>u</sup> (mg dL <sup>-1</sup> )	14.2	13.6	13.5	16.8	13.4	0.85	0.74	0.26	0.10	0.01
Change in PUN (mg dL <sup>-1</sup> )	3.9	6.9	6.3	6.5	6.0	1.46	0.19	0.68	0.99	0.75
Final glucose (mg dL <sup>-1</sup> )	57.3	50.0	50.5	52.2	56.8	2.49	0.18	0.20	0.14	0.13
Change in glucose (mg dL <sup>-1</sup> )	-2.6	-8.9	-11.1	-8.7	-2.7	3.94	0.29	0.72	0.20	0.22
Calf birth weight (kg)	40.3	45.2	45.2	42.9	41.8	3.36	0.56	0.31	0.84	0.74

<sup>2</sup>Values are least square means.

<sup>3</sup>100% Haylage = free choice haylage (pens = 2, cows = 7); 0.7% Haylage = haylage offered at 0.5% of BW for 36 d and 0.75% for remainder with free choice access to wheat straw (pens = 3, cows = 11); 1% Haylage = haylage offered at 1% of BW with free choice access to wheat straw (pens = 3, cows = 12); Haylage + SBM = haylage offered at 0.5% of BW plus soybean meal with free choice access to wheat straw (pens = 3, cows = 12); Haylage + DDGS = haylage offered at 0.5% of BW plus dried corn distillers grains plus solubles with free choice access to wheat straw (pens = 3, cows = 11).

<sup>x</sup>Contrast 1 = 100% Haylage vs. 1% Haylage, Haylage + SBM, and Haylage + DDGS; Contrast 2 = 0.7% Haylage vs. 1% Haylage, Haylage + SBM, and Haylage + DDGS; Contrast 3 = 1% Haylage vs. Haylage + SBM and Haylage + DDGS; Contrast 4 = Haylage + SBM vs. Haylage + DDGS.

<sup>w</sup>Body condition score on a 5-point scale, 1 = emaciated, 5 = obese.

<sup>v</sup>Intramuscular fat.

<sup>u</sup>Plasma urea N.

Haylage + DDGS. Change in BCS was different ( $P \leq 0.003$ ) from zero for all treatments except for 100% haylage ( $P = 0.24$ ; results not shown). Contrast statements were not significant for final BF thickness. Change in BF thickness tended to be less ( $P = 0.07$ ) in cows receiving 100% Haylage vs. other treatments, but did not differ between 0.7% Haylage vs. 1% Haylage, Haylage + SBM, and Haylage + DDGS, 1% Haylage vs. Haylage + SBM and Haylage + DDGS, and Haylage + SBM vs. Haylage + DDGS. Final intramuscular fat percent tended to be greater ( $P = 0.05$ ) in cows receiving 100% haylage vs. other treatments, but did not differ between 1% Haylage, Haylage + SBM, and Haylage + DDGS vs. 0.7% Haylage, 1% Haylage vs. Haylage + SBM and Haylage + DDGS, and Haylage + SBM vs. Haylage + DDGS. Contrast statements were not significant for change in intramuscular fat percent. Final PUN was greater ( $P = 0.01$ ) in cows receiving Haylage + SBM vs. Haylage + DDGS, but did not differ between 100% Haylage vs. others, 0.7% Haylage vs. 1% Haylage, Haylage + SBM, and Haylage + DDGS, and 1% Haylage vs. Haylage + SBM and Haylage + DDGS. Contrast statements were not significant for change in PUN, final plasma glucose concentration, and change in plasma glucose concentration. Contrast statements also were not significant for calf birth weight.

Using the average feed intakes for each of the dietary treatments from Table 2 and calculated net energy for

maintenance ( $NE_m$ ) of feed components from Table 1, estimated  $NE_m$  intakes were calculated. The estimated  $NE_m$  intakes [estimated relative to feed composition; Weiss et al. 1992; NRC 1996] were 19.17 Mcal d<sup>-1</sup> for 100% Haylage, 9.71 Mcal d<sup>-1</sup> for 0.7% Haylage, 12.06 Mcal d<sup>-1</sup> for 1% Haylage, 11.46 Mcal d<sup>-1</sup> for Haylage + SBM, and 13.08 Mcal d<sup>-1</sup> for Haylage + DDGS. The differences in net energy content in the diets closely mirror the observed results in ADG. Because cows receiving 100% Haylage consumed the greatest amount of feed and the highest-quality feed, greater BW gain was expected. Also, cows receiving 0.7% Haylage consumed the least amounts of energy and protein, resulting in lower ADG. Because calculated CP intake was similar between 1% Haylage, Haylage + SBM and Haylage + DDGS, it is most likely that increased growth was a result of increased energy in the supplement (as well as increased straw DMI) and not the level of protein. Interestingly, the improvement in ADG observed in cows receiving Haylage + SBM and Haylage + DDGS as compared with 1% Haylage also had increased straw DMI.

Using prediction equations from NRC (1996) and an average cow weight of 680 kg and 220 d pregnant, the estimated maintenance energy requirements for the pregnant beef cow is 13.1 Mcal d<sup>-1</sup>. The estimated  $NE_m$  intake was 19.17 Mcal d<sup>-1</sup> for 100% Haylage, 9.71 Mcal d<sup>-1</sup> for 0.7% Haylage, 12.06 Mcal d<sup>-1</sup> for

1% Haylage, 11.46 Mcal d<sup>-1</sup> for Haylage+SBM, and 13.08 Mcal d<sup>-1</sup> for Haylage+DDGS. With the exception of cows fed 100% Haylage, predicted NE<sub>m</sub> intakes were below the predicted requirements, yet cows generally maintained BF and a positive ADG, although pregnancy corrected ADG was negative for cows receiving 0.7% Haylage and 1% Haylage.

Changes in ADG could also be due to the variety of protein sources provided vs. using only a single protein source. Using a combination of protein sources (haylage plus soybean meal or dried corn distillers' grains plus solubles) in the diet is more likely to provide a more balanced profile of amino acids needed to satisfy the metabolizable protein requirements of the cow (Wilkerson et al. 1993). According to calculated values from NRC (1996), there were differences in the ratio of UIP/DIP to CP in the treatment diets; however, the effects of higher proportions of UIP on ADG in cows fed low-quality forage is likely minimal, since calculated DIP and MP intakes met or exceeded NRC (1996) requirements. Sletmoen-Olson et al. (2000), when investigating UIP supplementation levels in cows fed a low-quality prairie hay supplemented with a protein supplement containing 211g kg<sup>-1</sup> DM of DIP plus either low, medium or high (53, 223, 412, g UIP kg<sup>-1</sup>, respectively) UIP, found that there were no differences in weight gain, BCS or subsequent calf performance between any of the supplemental treatments, indicating that supplementation of UIP is of little value when supplemental DIP is adequate to sustain rumen function. Therefore, increases in ADG in cows receiving Haylage+SBM and Haylage+DDGS were likely due to both increased straw intake and increased energy content of the supplement and not differences in protein degradability.

The results from the ultrasound measures of fatness in the current experiment do not support dietary treatment differences in BW gain or body condition scoring. Cows on this trial were all well conditioned, maintaining BF of over 14 mm on average throughout the trial. Since these cows were in good condition, these small changes in BCS and ultrasound BF do not likely have any major effects on productivity. It is possible that the loss/gain of body fat occurred in a location other than the BF. Visceral fat accounts for approximately 30% of total body fat (Cianzio et al. 1982). Past research has suggested that as much as 60% of visceral fat can be mobilized in lactating dairy cattle when metabolic demands are not met by the diet (Baldwin et al. 2004). Although visceral fat is difficult to measure in the live animal and was not measured in the present study, it is possible that the observed differences in weights came from the mobilization or deposition of visceral fat, rather than the mobilization or deposition of BF, since BF did not differ between treatments. In addition, a study examining the differences in maintenance energy requirements between thin and fat cows of Angus-Hereford breeding suggests that the maintenance energy

requirements for cows that are fat are 6.1% lower than those of thin cows (Thompson et al. 1983).

The lower final PUN concentration in cows fed Haylage+DDGS than cows fed Haylage+SBM may be an indication that there are differences in protein degradability and protein utilization between SBM and the other protein supplements (haylage or DDGS), which may be influencing PUN concentrations, although differences in PUN between treatments were relatively small and change in PUN over the experiment did not differ between treatments. Our results indicating no difference in calf birth weights agree with the findings of Stalker et al. (2006), who found no differences in calf birth weights between cows offered a protein supplement or those fed hay compared with cows grazing on meadow pastures pre-partum.

In conclusion, providing wheat straw for ad libitum intake in wintering cows appears to be an acceptable alternative to providing haylage for ad libitum intake providing adequate levels of supplementation are provided to ensure sufficient nutrient intake. The supplementation of the diet with SBM or DDGS plus haylage increased straw DMI and cow weight gain versus only supplementing with haylage.

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