Effect of crop residues in haylage-based rations on the performance of pregnant beef cows

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Wood, K. M., Kelly, M. J., Miller, S. P., Mandell, I. B. and Swanson, K. C. 2010. **Effect of crop residues in haylage-based rations on the performance of pregnant beef cows**. Can. J. Anim. Sci. **90**: 69–76. Seventy-one individually fed multiparous, pregnant crossbred beef cows [body weight (BW) ± SD; 730 ± 77.9 kg] were used to examine the effects of including crop residues in alfalfa/grass haylage-based rations on BW gain, fat deposition/loss and plasma metabolites. The haylage control ration (CON; $n = 23$) was modified to include either 40% (dry matter basis) wheat straw (WS; $n = 24$) or 40% corn stalklage (CS; $n = 24$). Cows were blocked by calving date and randomly assigned to each treatment and fed for 82 d leading up to the earliest calving date. On days 1, 40, and 82, cows were weighed, ultrasounded to measure subcutaneous backfat (BF) over the ribs, body condition scored (BCS) and plasma was collected. Calves from cows fed WS had greater ($P = 0.02$) weaning weights than cows fed CS, but did not differ ($P = 0.23$) from CON. CS cows had the lowest ADG ($P < 0.03$), lost the most body condition ($P < 0.04$), and had the lowest dry matter intake ($P \leq 0.001$). These data indicate that diets containing crop residues can be used to dilute high-quality haylage rations for wintering beef cows; however, diets containing 40% corn stalklage used in this experiment may not be advisable, since cows lost BW and fat, and their calves had the poorest calf performance up to weaning.

Key words: Beef cattle, wheat straw, winter feeding, corn stalklage, crop residues

Wood, K. M., Kelly, M. J., Miller, S. P., Mandell, I. B. et Swanson, K. C. 2010. **Incidence des déchets de culture dans les rations de mi-fané sur la performance des vaches de boucherie gravides**. Can. J. Anim. Sci. **90**: 69–76. Soixante et onze vaches de boucherie hybrides, multipares et gravides (poids corporel ± É.-T.; 730 ± 77,9 kg), nourries individuellement, ont servi à préciser les conséquences des résidus agricoles présents dans les rations de mi-fané de luzerne et de graminées sur le gain de poids, le rapport entre le dépôt et la perte de matière grasse, et les métabolites du sang. Les auteurs ont modifié la ration témoin de mi-fané (CON; $n = 23$) afin qu'elle inclue 40 % (d'après la quantité de matière sèche) de paille de blé (WS; $n = 24$) ou 40 % d'ensilage de tiges de maïs (CS; $n = 24$). Les vaches ont été réparties selon la date de vêlage, puis affectées au hasard à un traitement avant de recevoir la ration pendant 82 jours jusqu'à la première date de vêlage. Les animaux ont été pesés le 1er, le 40e et le 82e jour. On a aussi mesuré le gras dorsal sous-cutané aux ultrasons à hauteur des côtes, établi la note d'état corporel et prélevé du sang. Les veaux des vaches nourries avec du WS étaient plus lourds ($P = 0,02$) au sevrage que ceux des vaches recevant du CS, mais ils avaient le même poids ($P = 0,23$) que les veaux du groupe CON. Les vaches du groupe CS ont enregistré le gain de poids quotidien le plus faible ($P < 0,03$), ont vu leur état corporel se dégrader le plus ($P < 0,04$), et ont ingéré le moins de matière sèche ($P \leq 0,001$). Ces résultats indiquent qu'on pourrait utiliser une ration contenant des déchets de culture pour diluer les rations de mi-fané de haute qualité durant l'hivernage des vaches de boucherie; cependant, les rations contenant 40 % d'ensilage de tiges de maïs employées dans le cadre de cette expérience pourraient ne pas convenir, puisque les sujets ont perdu du poids et du gras, et leurs veaux étaient les moins performants au vêlage.

Mots clés: Bovins de boucherie, paille, alimentation hivernale, ensilage de tiges de maïs, déchets de culture

In the beef cow/calf production system, nutritionally sustaining pregnant cows over the winter months, when grazing options are limited or unavailable, can represent a significant cost to the producer. 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 [as reported by McCartney et al. (2006)]. There may be opportunities to keep winter feeding costs low by utilizing lower quality and lower cost forages, such as crop residues from grain corn and cereal grains. These crop residues may provide up to 50 to 60% of the feed [% dry matter (DM) basis] needed to maintain the pregnant beef cow over winter. However, an additional nutrient source is needed to sustain acceptable animal performance, prevent rumen impaction, maintain

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Abbreviations: **ADF**, acid detergent fibre; **BF**, backfat; **BCS**, body condition score; **BW**, body weight; **CP**, crude protein; **CS**, corn stalklage; **DM**, dry matter; **DMI**, dry matter intake; **DON**, deoxynivalenol; **NDF**, neutral detergent fibre; **NDFD**, neutral detergent fibre digestability; $\mathbf{NE_m}$, net energy for maintenance; **PUN**, plasma urea dry matter intake (DMI), and improve digestibility (Pritchard and Males 1982, 1985; Wiedmeier et al. 1983; Bohnert et al. 2002; Tellier et al. 2004). Diluting higher quality feeds by incorporating lower quality forages may be a strategy to meet nutrient requirements without negatively affecting cow-calf performance and without the use of expensive supplemental protein sources or grains.

Cereal straws in particular have been extensively studied as a low cost winter feedstuff for beef cows (Tellier et al 2004; McCartney et al. 2006). Much of the research has focused on additives and treatments of straws to improve nutritive value and digestibility by processes such as ammoniation (Males 1987). There has been very little research into the use of wheat straws (WS) in total mixed rations containing high-quality forages such as haylage, with no additional protein supplement for wintering beef cows.

With the recent expansion in ethanol production, corn acreage has dramatically increased over the past 10 yr (Statistics Canada 2008). Corn stalk crop residues have been used primarily as a feed source for beef cattle in winter grazing systems (Hitz and Russell 1998). Corn stalklage can be used successfully as a forage source for ruminants (Colenbrander et al. 1971; Klopfenstein et al. 1987; Lopez-Guisa et al. 1991; Collins and Pritchard et al. 1992), but similar to WS, information is limited on the efficacy of feeding corn stalklage as a winter forage source for beef cows either alone or in combination with haylage containing no grain supplements.

Although the nutrient requirements of the beef cow are relatively low during the winter months prior to parturition and lactation, proper nutrition must be considered in order to ensure the future success of the cow and calf. Meeting the nutritional requirements of the pregnant cow is important to ensure the cow is of adequate condition to calve, lactate and rebreed, and for the proper growth and development of the fetus [National Research Council (NRC) 1996]. Prepartum body condition score has been positively linked to increased weaning weights of the calf (Stalker et al. 2006), while inadequate nutrition pre-calving can negatively impact the first post-calving return to estrus (Randel 1990).

The objective of this experiment was to examine the effect of including two different crop residues in alfalfa/grass haylage-based winter cow rations on the performance of pregnant beef cows and subsequent performance of their calves up to weaning.

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. Seventy-one mature pregnant beef cows [body weight (BW) = 730 kg ± 77.9, body condition score (BCS) = 3.0 ± 0.39, and backfat (BF) = 10.1 mm ± 4.34, days pregnant = 169 d ± 14] were selected from the cow herd at the Elora Beef Research Centre in Elora, Ontario. Cows were of primarily Angus and Simmental breeding and were bred to Angus, Simmental or crossbred bulls of predominately Angus and Simmental breeding of similar genetic merit. Sires and sire-breeds were randomly distributed between treatments. The cows were blocked by predicted calving date and randomly assigned to one of three dietary treatments: the control treatment (CON; $n = 23$) consisting of alfalfa haylage, WS treatment ($n = 24$) with 40% (DM basis) of the haylage ration replaced by WS, and the corn stalklage treatment (CS; $n = 24$) with 40% (DM basis) of the haylage ration replaced by corn stalklage. All diets contained 0.5% (DM) of a commercial beef cow vitamin and mineral premix to meet or exceed dietary requirements (NRC 1996; Table 1). The corn stalklage was harvested following harvest of high moisture grain corn and chopped similarly to corn silage, and then ensiled into a bunker silo. A commercially available inoculant containing *Lactobacillus* and *Enterococcus* cultures was applied at a rate of 250 mL $tonne^{-1}$. Since, mould was visible on the top portion of the silage, approximately 20 cm of the outer shell was discarded prior to feeding. The diets were fed as a total mixed ration (TMR), ad libitum for 82 d over the winter months (January to March), leading up to the first expected date of parturition. The average temperature for the experimental period was −5.9°C, ranging from an average minimum temperature of −10.2°C to an average maximum temperature of −1.7°C (National Climate Data and Information Archive 2009).

Table 1. Diet composition and analyses

	Dietary treatment		
	CON	CS	WS
Ingredient[z]			
Haylage[y]	99.5	59.5	59.5
Corn stalklage	–	40.0	–
Wheat Straw	–	–	40.0
Vitamin/mineral premix[x]	0.5	0.5	0.5
Analyses[w]			
DM (%)	36.7	27.4	47.6
CP (%)[z]	18.3	11.4	11.7
NDF (%)[z]	49.5	63.4	64.5
ADF (%)[z]	42.2	51.0	50.6
NE_m (Mcal kg^{-1})[v]	1.50	1.43	1.40
NE_g (Mcal kg^{-1})[v]	0.78	0.71	0.68

[z]% DM basis.
[y]Contains approximately 80% alfalfa and 20% grasses (timothy and orchard primarily).
[x]Floradale Feed Mill 1:1 Cattle Premix with Salt contains 13% calcium, 13% phosphorus, 5% sodium, vitamin A 600 000 IU kg^{-1}, vitamin D 200 000 IU kg^{-1}, vitamin E 1000 IU kg^{-1}, selenium 30 mg kg^{-1}.
[w]Average of weekly TMR samples.
[v]Calculated according to Weiss et al. (1992) and NRC (1996).

Sample Collection

On days 1, 40, and 82, cows were weighed, body condition scored, ultrasounded for BF and a blood sample obtained via jugular venipuncture. All cows were fed the same diet prior to the experiment and body weights were taken on 2 consecutive days at the beginning of the experiment. Feed samples (TMR) were obtained weekly and frozen at −20°C for future analysis. Ultrasound measurements of subcutaneous BF thickness were taken between the 12th and 13th rib using an Aloka SSD-500 ultrasound unit (Corometrics Medical Systems, Wallingford, CT). Body condition scoring was done on a five-point scale by the same individual for the entire trial period and on a scale of 1 to 5 where 1 was considered emaciated and 5 was obese (Ontario Farm Animal Council 2009). Feed intakes for individual cows were measured using the Calan gate system (American Calan, Inc., Northwood, NH) with feed refusals measured on a weekly basis. Feed was provided so that animals would consume the majority of feed provided using a slick bunk management approach (Pritchard and Bruns 2003). Calf birth weights and calving ease scores were recorded at the time of parturition. Calving ease was recorded as unassisted, easy pull, or hard pull. All records for twins were removed from the data set (CS, $n=2$; WS, $n=3$). All calves were born between 2007 Mar. 31 and 2007 May 26. Following parturition, cows were maintained on dietary treatment rations until moved to a managed pasture system approximately 4 to 5 wk post-calving. The cows were re-blocked, such that nutritional treatments were balanced across each pasture paddock. On pasture stocking density was approximately 2.47 cow/calf pairs ha^{-1}, such that forage availability was not limiting. All calves were weaned on 2007 Oct. 31 and an individual calf weaning weight was recorded.

Laboratory Analysis

All feed analysis was completed at Agri-Food Laboratories Inc. (Guelph, ON). Weekly TMR samples were dried at 55°C and then ground to pass through a 1-mm screen. DM analysis was conducted in accordance with the Association of Official Analytical Chemists guidelines (1990, Method 930.15.). Percent crude protein (CP) was determined by multiplying 6.25 by percent dietary nitrogen as determined by a Leco N analyzer (Leco Corporation, St. Joseph, MI). Acid detergent fibre (ADF) and neutral detergent fibre (NDF) values were determined using the methods of Robertson and Van Soest (1981) using an Ankom fibre analyzer (Ankom Technology Corp., Fairport, NY). In vitro NDF digestibility (NDFD) of composite samples of the three main individual feedstuffs (alfalfa/grass haylage, WS and CS) were determined using an Ankom Daisy II incubator (Ankom Technology Corp., Fairport, NY). The feedstuffs were added to individual filter bags and incubated for 0, 6, 12, 18, 24 and 48 h; bags were removed from the incubator and residue was analysed (Dado and Allen 1996) for NDF content using the method previously described. Additionally, a subset of four samples of the ration components was pooled and analyzed for trichothecene mycotoxins (nivalenol, 15-ADON, 3-ADON, Neosolanion, DAS, HT-2 and T2) using gas chromatography with ion-trap mass spectrometer detection using acetonitrile chemical ionization (Canadian Food Inspection Agency 2007) at the University of Guelph Laboratory Services (Guelph, ON).

Blood samples were centrifuged at 3000 × *g* for 20 min and plasma was separated and then frozen at −20°C until analyzed. Plasma urea nitrogen (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

The trial was analyzed as a randomized complete block design using the MIXED procedure of SAS (SAS Institute, Inc. 2008). The model included the effects of block (parturition due date), parity, and dietary treatment. The model for calf birth weight also included the effect of calf sex. The model for calving ease also included the effects of calf sex and birth weight, while the model for calf weaning weight also included the effect of calf sex and the summer pasture field. Pen was included as a random effect. A Brown and Forsythe test was conducted to confirm homogeneity of variance between treatment groups. A Tukey-Kramer test was used to compare means between all dietary treatment groups with $P \leq 0.05$ used to indicate significance. Data are presented with main effect P values in tables and Tukey-Kramer P values in text.

RESULTS

On days 1 and 40, BW did not differ ($P>0.10$) between treatment groups (Fig. 1). On day 82, cows fed CON were heavier ($P=0.01$) than cows fed CS, but cows fed WS remained intermediate ($P>0.11$) in BW to cows fed CON and cows fed CS. Over the course of the trial, cows fed CON had the greatest ADG, while cows fed CS had a negative ADG; ADG for all dietary treatment groups differed ($P<0.03$; Table 2) from each other. Body condition scores also followed a similar pattern to ADG with cows fed CON gaining more body condition over the trial period than cows fed WS ($P=0.03$) and cows fed CS ($P=0.01$), while cows fed WS lost less body condition than cows fed CS ($P=0.04$). On day 82, BCS was 3.4, 2.5, and 3.0 (SEM $=0.1$) for CON, CS, and WS, respectively (data not shown). When quantifying the measure of fatness using the ultrasound measurements for subcutaneous BF, cows fed CON gained more BF than cows fed CS ($P=0.001$) and cows fed WS ($P=0.02$) over the trial period. The DMI for cows fed CON was greater than for cows fed CS and cows fed WS

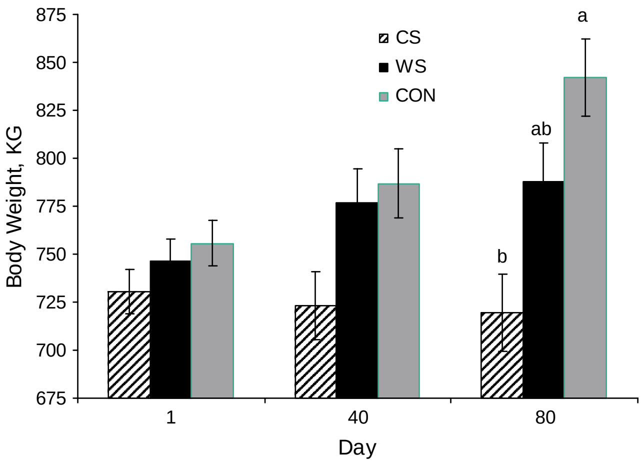

Fig. 1. Influence of crop residue inclusion on actual body weight on days 1, 40, and 80. Values reported are LSM ± SEM. Means not sharing the same letter within sampling day differ significantly ($P < 0.05$). CON = control ration ($n = 23$); CS = corn stalklage treatment ($n = 24$); WS = wheat straw treatment ($n = 24$).

($P < 0.001$ and $P = 0.04$, respectively) and cows fed CS consumed less ($P = 0.001$) DM than cows fed WS.

When examining individual sampling periods for plasma metabolites on day 1, PUN concentration and plasma glucose concentration were similar ($P > 0.73$; Table 3) across all dietary treatments. On trial day 40, PUN was greater ($P = 0.01$) for cows fed CON than CS cows, but not for cows fed WS ($P = 0.35$), while WS cows did not differ ($P = 0.06$) in PUN concentration when compared with cows fed CS. On day 82, PUN concentration in cows fed CON was greater ($P = 0.02$) than cows fed CS, but not greater ($P = 0.09$) than cows fed WS. There was no difference ($P = 0.53$) in PUN concentration between cows fed WS and cows fed CS on day 82. On day 40, plasma glucose concentrations did not differ ($P \geq 0.09$) between dietary treatments. On day 82, plasma glucose concentrations were greater in cows fed CON than in cows fed CS ($P = 0.01$) and cows fed WS ($P = 0.01$) but did not differ ($P = 0.97$) between cows fed WS and cows fed CS.

There was no difference between dietary treatment groups for calf birth weight ($P > 0.88$) or calving ease score ($P > 0.52$; Table 4). Cows fed WS had heavier ($P = 0.02$) calves at time of weaning than cows fed CS but did not differ ($P = 0.23$) from cows fed CON. Calf weaning weights did not differ ($P = 0.33$) between cows fed CON and cows fed CS.

DISCUSSION

Performance

Using alternative winter feeding programs containing crop residues can be a means of reducing winter feed costs; however, the adequate condition of cows leading up to parturition must be maintained, as it becomes an important factor in the performance of the cow and calf during parturition and lactation. By the end of the 82-day trial period, cows fed CON were heavier and had greater BCS than cows fed CS, while WS cows were intermediate in BW and BCS to cows fed CON and CS. These measures of performance over the prepartum period may indicate that cows fed CS may be in a state of negative energy balance, since CS cows lost body condition in a crucial period prior to parturition. CON animals gained a large amount of weight and body condition while WS remained intermediate to CON, indicating that perhaps energy requirements were satisfied.

The observed differences in body weight and condition in cows fed CS and WS rations were not likely due to differences in the nutrient composition between CS and WS rations (Table 1). The CS and the WS TMRs were very similar in CP, ADF, NDF, and net energy for maintenance (NE_m) and yet the WS cows outperformed the cows fed CS. The CON ration was much higher in CP and NE_m and, as expected, CON cows had the greatest weight gain over the pre-partum period. Dry matter intake was significantly greater for cows fed CON than for cows fed CS and WS. Cows fed CS consumed less feed than cows fed WS and the dramatically lower feed intakes by CS cows was likely the

Table 2. Influence of crop residue inclusion on pregnant beef cow performance and dry matter intake

	Dietary treatment[z]				*P* value
Item	CON	CS	WS	SEM	*P* > *F*
Average daily gain (kg d^{-1})	1.07*a*	−0.13*b*	0.51*c*	0.77	0.001
DMI (kg d^{-1})	12.8*a*	6.7*b*	10.9*c*	0.42	<0.001
Change in BCS[yx]	0.3*a*	−0.3*b*	−0.04*c*	0.06	0.002
Change in subcutaneous backfat[y] (mm)	3.8*a*	−0.5*b*	1.3*b*	0.48	0.002

[z]Dietary treatment: CON = control ration ($n = 23$); CS = corn stalklage treatment ($n = 24$); WS = wheat straw treatment ($n = 24$).
[y]Change is the difference between the final value (day 82) and the initial value (day 1).
[x]BCS was recorded on a 5-point scale. 1 = emaciated; 5 = obese.
a–c Values reported are LSM and SEM for the treatment with the lowest number of observations ($n = 23$). Means in a given row not sharing the same letter differ ($P < 0.05$).

Table 3. Influence of crop residue inclusion on plasma metabolite concentrations over the trial period

Item	Dietary treatment[z]			SEM	*P* value
	CON	CS	WS		*P* > *F*
Day 1					
Plasma urea N (mg dL^{-1})	7.8	8.9	7.7	1.13	0.72
Glucose (mg dL^{-1})	68.2	67.2	68.0	3.24	0.98
Day 40					
Plasma urea N (mg dL^{-1})	13.1*a*	9.0*b*	11.7*ab*	0.66	0.01
Glucose (mg dL^{-1})	67.1	60.1	63.0	1.84	0.09
Day 82					
Plasma urea N (mg dL^{-1})	12.5*a*	9.6*b*	10.4*ab*	0.55	0.03
Glucose (mg dL^{-1})	61.1*a*	54.0*b*	54.4*b*	1.22	0.008

[z]Dietary Treatment: CON = control ration (n = 23); CS = corn stalklage treatment (n = 24); WS = wheat straw treatment (n = 24).
a–c Values reported are LSM and SEM for the treatment with the lowest number of observations (n = 23). CON = control ration (n = 23); CS = corn stalklage treatment (n = 24); WS = wheat straw treatment (n = 24). Means in a given row not sharing the same letter differ ($P < 0.05$).

cause of reduced performance when compared with cows fed WS. Using the average feed intake for each dietary treatment (Table 2) and the predicted NE_m from feed component analysis (Table 1), estimated NE_m intake was 19.2, 9.6 and 15.3 Mcal d^{-1} for cows fed CON, CS and WS, respectively. The increased intakes and higher energy density of the CON ration were most likely responsible for the increased gains in BW, body condition, and BF for cows receiving this treatment. Other factors that affect DMI are likely responsible for the observed depression in DMI for cows fed CS.

Reduced digestibility has been shown to limit DMI by reducing rate of passage (Colucci et al. 1981). The 48 h NDFD for the composite sub-sample of ingredients was very similar between WS and CS samples and the alfalfa/grass haylage had a greater extent of digestibility than the crop residues (Fig. 2). Differences in the digestibility of corn stalklage is not likely the cause of the observed differences in DMI, since the 48 h in vitro NDFD were similar between the WS and the CS over the entire 48 h digestibility curve. It is unlikely that digestibility is limiting DMI in cows fed CS.

Research has indicated that deoxynivalenol (DON) contamination can be implicated in reduced DMI and feed refusal in swine diets (Smith et al. 1997; Dänickel et al. 2005); however, the effects of DON on feed intake in ruminants are less conclusive. Mycotoxin levels for the ration components were below the detectable limits for all constituents except for the corn stalklage sample, which contained 0.077 μg g^{-1} DON. Due to ruminal fermentation and potential metabolism of mycotoxins, the effects of mycotoxins on ruminants are thought to be minimized (Seeling et al. 2006). However Trenholm et al. (1985) reported a slight reduction in feed intake as dry dairy cows were switched from a low to a high (6.4 mg kg^{-1}) DON diet. Conversely, Charmley et al. (1993) investigated the effects of varying levels of DON in lactating dairy cow rations and found no difference in DMI between any of the inclusion levels which were up to 12 mg kg^{-1} of concentrate DM. Similarly, Ingalls (1996) found that diets containing DON up to 14.6 mg 100 kg^{-1} did not have any effect on feed intake in dairy cows. Since the DON level present in the corn stalklage in the current trial was only 0.077 μg g^{-1}, and was considerably lower than DON concentrations found in the above listed trials, the effect of DON on voluntary feed intake in the CS fed cows was likely negligible. However, the effects of depressed DMI from other mycotoxins not measured in the corn stalklage cannot be ruled out as some visible mould on outer shell of ensiled corn stalklage, although discarded, was observed.

Differences in CS ration particle size may have resulted in increased feed sorting behaviour and reduced DMI. Particle size in corn stalklage, although not

Table 4. Influence of crop residue inclusion on beef cow/calf performance

Item	Dietary treatment[z]			SEM	*P* value
	CON	CS	WS		*P* > *F*
Calf birth weight (kg)	43.2	44.3	44.3	1.68	0.86
Calving ease score[y]	1.3	1.5	1.2	0.18	0.52
Calf weaning weight (kg)	266*ab*	253*a*	282*b*	13.4	0.02

[z]Dietary treatment: CON = control ration (n = 23); CS = corn stalklage treatment (n = 24); WS = wheat straw treatment (n = 24).
[y]Calving ease was scored on a three point system, where 1 was unassisted, 2 was easy pull, and 3 was hard pull.
a–c Values reported are LSM and SEM for the treatment with the lowest number of observations (n = 23). CON = control ration (n = 23); CS = corn stalklage treatment (n = 24); WS = wheat straw treatment (n = 24). Means in given row not sharing the same letter differ ($P < 0.05$).

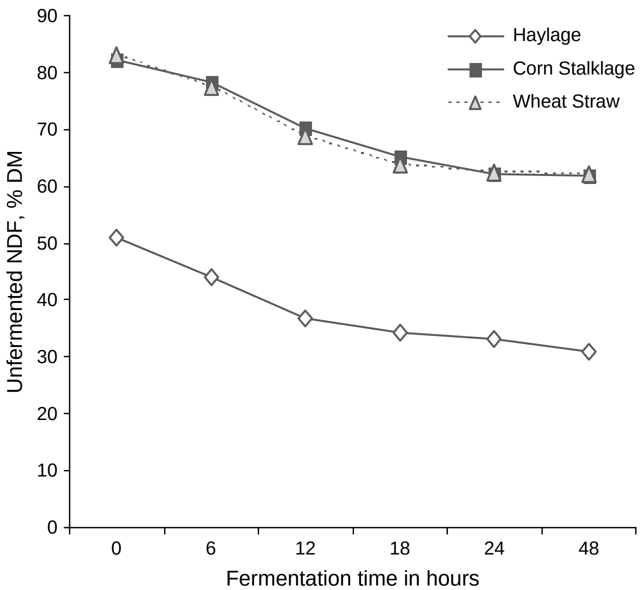

Fig. 2. In vitro digestion of neutral detergent fibre in ration components incubated over a 48-h time period.

measured in this experiment, appeared bulkier than wheat straw and may be contributing to differences in feed intake. Feed sorting behaviour in cows fed total mixed rations has primarily been researched in dairy cows. The literature suggests that as particle size of a ration component increases, DMI decreases (Kononoff et al. 2003; Leonardi and Armentano 2003; DeVries et al. 2007). Kononoff et al. (2003) observed a difference in DMI of over 2 kg d^{-1} between cows fed a TMR containing short particle corn silage than those fed a TMR containing long particle corn silage. These and other characteristics related to palatability could be a contributing factor in the drop in DMI observed in the CS treatment.

Blood Metabolites

By measuring plasma urea nitrogen and glucose concentrations in the plasma throughout the trial period, an indication of the effect of the rations on protein status and energy metabolism can be observed (Swanson et al. 2007). The observed changes in plasma urea nitrogen concentration reflect the observed changes in body condition and weight. On days 40 and 80, cows fed CS had significantly lower PUN concentration than CON cows. This is likely caused by lower DMI coupled with differences in CP concentrations in the diets, resulting in lower total crude protein intakes. Differences in plasma glucose concentration between the cows fed crop residues and the control group are likely due to differences in nutrient composition between CON and the two dietary treatments containing crop residues (WS and CS). The higher concentrations of NDF and ADF in rations containing crop residues would result in lower amounts of readily available rumen fermentable carbohydrate and thus less propionate available for gluconeogenesis (Sarwar et al. 1992).

Corrected Live Weight Gain

Actual BW change in pregnant beef cows can be difficult to assess due to the growth of the fetus, uterus and associated tissues. Silvey and Haydock (1978) used two exponential models using polynomial coefficients to estimate fetal weights and gravid uterus and membrane weights using calf birth weight and time of gestation. By using these equations, corrected live body weight gains can be calculated to account for fetal growth. Using the average time of gestation and the least square means for calf birth weight and cow body weight for day 0 and day 82, a corrected live body weight change was calculated. CON cows gained an estimated 49.1 kg, while CS cows lost 49.6 and WS cows gained 2.4 kg. Because WS cows maintained their bodyweight, the WS diet likely met all the nutrient requirements and would likely be the most efficient winter cow ration. Using prediction equations from NRC (1996) for a mature cow with a body weight of 680 kg and 220 d pregnant, the estimated NE_m requirement is 15.5 Mcal d^{-1}. The calculated NE_m intakes of cows fed WS most closely match recommendations suggested by NRC (1996). The weight gained by CON cows may not be as efficient from a production stand point, since DMI and estimated NE_m intake were greater for cows fed CON versus cows fed rations containing crop residues. However, calf weaning weights for cows fed CON were numerically lower than weaning weights for calves from cows WS. This corrected live body weight change is supported by the results of the BCS and the measured rib fat, which illustrates this change in actual BW. This corrected live weight gain/loss may also have lasting implications in the post-partum period.

Calf Performance

Since the majority of revenue in cow/calf production is dependent on the cow weaning a live, healthy, and heavy calf, measures of subsequent performance of the calf are important to consider. In this experiment, calf performance was important to observe due to the dramatic differences in cow growth and body condition observed in the pre-partum period, which may possibly have long-term impacts on the overall productivity of the cow. At parturition, there were no observed differences in calf birth weight or calving ease between dietary treatments. This is supported by previous findings (Stalker et al. 2006; Perry et al. 1991), who also observed similar birth weights, regardless of prepartum nutritional regimen. Bassett (1986) suggested that even when the nutrition of the mother is deficient, the conceptus can compensate by relying on nutrient sources derived from the maternal tissues in order to maintain growth.

At the time of weaning, calves from cows fed CS had significantly lower weaning weights than calves from cows fed WS (Table 4). It is likely that the low DMI created a dietary energy deficiency prepartum, which resulted in poorer milk production postpartum. This is supported by Perry et al. (1991) who suggested that feeding an energy-deficient diet for 100 d prepartum to crossbred heifers and 2-yr-old cows resulted in calves that were lighter at 70 d post partum when cows were fed the same rations post partum. These energy-restricted cows also had significantly lower milk production than high-energy-fed cows. Stalker et al. (2006) also found that when grazing cows were fed a protein supplement prepartum, calves had improved weaning weights. Calf weaning weights from cows fed CON were intermediate to WS and CS. It is possible that the cows fed CON became over conditioned and this negatively impacted milk production and therefore calf weaning weight. This is supported by Arnett et al. (1971) in an investigation into the effects of obesity in beef females. Normal body conditioned cows produced significantly more milk over three lactations than obese beef cows and, in addition, calves of the normal conditioned cows tended to gain weight more rapidly and be heavier at weaning than calves who nursed from obese cows. Although cows fed CON were not obese by definition of the body condition scoring system used in this experiment, these cows had a significantly greater BCS on day 82 than cows fed WS or CS and the additional body fat may have influenced subsequent milk production. Our data indicate that cows fed WS would be the most desirable in terms of calf performance, since weaning weights of calves were greater from cows fed WS than from cows fed CS and numerically higher than weaning weights of calves from cows fed CON.

CONCLUSIONS

This experiment demonstrates that incorporating wheat straw into a high-quality haylage-based TMR at a 40% inclusion level is a viable alternative to feeding ad libitum haylage. These data indicate that the WS ration may be the most ideal since the corrected live weight gain was close to 0 and performance of the WS cow's calves at weaning was superior. Cows fed CON gained the most weight, body condition, and rib fat, and had the greatest DMI and corrected body weight gain. Since calves from CON cows did not show improved performance at weaning, this indicates that these animals may not be as efficient. Diets containing 40% corn stalklage in a haylage-based TMR are not recommended as a means of reducing winter feed costs, since the cows had decreased performance and depressed feed intake. Further work is needed in order to determine if lower inclusion rates of corn stalklage in winter cow rations are feasible or if differences in composition, harvesting, and storage of corn stalklage influences cow performance.

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