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HAY SUBSTITUTION WITH A FIELD PEA-BASED BLENDED RDP-RUP COMPOUND SUPPLEMENT FED DAILY OR ON ALTERNATE DAYS TO GESTATING-LACTATING BEEF COWS

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Abstract

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To evaluate a forage mitigation strategy, third trimester beef cows were used to determine the effect on subsequent beef cow performance when 28.1% of forage dry matter (DM) was replaced with a nutrient-dense pelleted rumen degradable protein-rumen undegradable protein supplement (RDP-RUP) fed daily (**D**) or on alternate days (**Alt-D**).In the 111 day study, one hundred seven,3-10 year old beef cows, were randomized to the following treatments: 1) all hay control group ©, 2) hay and strawforagethat was reduced 28% and replaced with a field pea-barley malt sprout-distillers dried grain with solubles supplement (PEA-BMS-DDGS) fedD at 0.25% of initial body weight(BW) or, 3) hay and straw foragethat was reduced 28% and replaced witha PEA-BMS-DDGS fed on Alt-D at 0.50% of initial BW. Control cows consumed 14.1 kg of hay compared to supplemented cows that consumed 8.10 kg hay, 2.03 kg straw, and 1.37 kg of supplement daily for a total of 11.5 kg. The experimental supplement that was fed supplied 61% RDP and 36% RUP. Reducing hay in the experimental diets and replacing it with wheat straw and the PEA-BMS-DDGS supplement fed either D or on ALT-D did not affect ending cow BW, body condition score, fat thickness, pre-breeding estrous cyclicity, reproductive cycle pregnancy, or the total percent of cows pregnant ($P > 0.10$). Control and Alt-D calf birth weight was heavier than the D supplemented group ($P < 0.01$). Calfweaning weight and gain did not differ ($P > 0.10$). Biologically, there was no difference between C and supplemented cows throughout the study and it was determined that one unit of PEA-BMS-DDGS supplement could replace 2.9 units of forage. On average, and on the basis of 100 cows supplemented for the 111 day period, 15.1 mt of supplement replaced 44.1 mt of forage ($P<0.001$). Compared to feeding the all hay C diet,the cost of replacing hay with wheat straw and the nutrient-dense PEA-BMS-DDGS supplement was $287.54, $304.44, and $302.43 per cow for the C,D, and ALT-D treatments, respectively. The slightly higher cost for supplementation in the drought mitigation strategy tested wasminiscule compared to selling cows to fit the available forage supply. These data suggest that adequate nutrient supply to the rumen and small intestine can be obtained when feeding a PEA-BMS-DDGS on ALT-D and that the dietary strategy can be used to mitigate drought related hay shortages.

Key words: beef cows, barley malt sprout, distillers dried grain with solubles, field pea, rumen degradable protein, rumen undegradable protein

Abbreviations: ADF - acid detergent fibre; ADG - average daily gain, Alt-D - alternated days; BCS - body condition score; BMS - barley malt sprout; BW - body weight; C^{2+} - calcium; C - control group; CP - crude protein; D - daily; DDGS - distillers dried grain with solubles; DM - dry matter; IVDMD - *in vitro* dry matter disappearance; IVOMD - *in vitro* organic matter disappearance; NDF - neutral detergent fibre; OM - organic matter; PEA - field pea; PEA-BMS-DDGS, field pea-barley malt sprout-distillers dried grain with solubles blended supplement; P - phosphorus; PR - pregnancy rate; RDP - rumen degradable protein; RUP - rumen undegradable protein; SF - supplementation frequency; TDN - total digestible nutrients

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Introduction

Precipitation shortages limit forage production and hay supplies, which are the mainstay for beef cattle production. Since drought is common approximately one-third of the time in western North Dakota (Manske et al., 2010), producers must decide between selling cows, or using a forage/supplementation management strategy that will replace a portion of the hay that could not be harvested. One alternative to selling cows is to replace large quantities of forage with a nutrient dense supplement containing a balance of rumen degradable (RDP) and rumen undegradable protein (RUP) fed daily (D) or on alternate days (ALT-D).

Crops and co-products from agricultural processing in the northern Great Plains region of the United States produce large quantities of feedstuffs like field pea (PEA), barley malt sprouts (BMS), and distillers dried grain with soluble (DDGS) that contain varying amounts of rumen degradable protein (RDP) and rumen undegradable protein (RUP), which are suitable ingredients for formulating a RDP-RUP supplement.

When nutrient-dense supplements are fed on the ground to range cows in an alternate day feeding system, the supplement must possess high pellet integrity and must not induce bloat or a rapid decline in rumen pH post feeding. The starch degradation rate of field pea (*Pisum sativum*) is similar to corn (Robinson and McQueen, 1989) and the RDP ranges from 78 to 94% (Aufrere et al., 2001; National Research Council, 1989). Barley malt sprouts average 16% crude protein (CP), 74% total digestible nutrients (TDN), the fiber component is of moderate to high digestibility, and the RUP content is 35.8% (Lardy and Anderson, 2009). DDGS are a source of RUP, energy, and minerals (Stock et al. 2000), and as a percent of CP, DDGS contain approximately 65% RUP, which can be beneficial when balancing cattle diets for metabolizable protein (Patterson et al., 2003). Although there is a large volume of research evaluating the use of supplements with high RUP properties like DGGS for growing and finishing cattle (Depenbusch et al., 2008; Klopfenstein et al., 2008; May et al., 2010; Uwituze et al., 2010), information on the effects of supplementing DDGS in gestating and lactating beef cow diets is less prevalent (Radunz et al., 2010; Winterholler et al., 2012).

Protein supplementation, as infrequently as once every six to ten days, with either cottonseed meal or soybean oil meal that provided >20% RUP have been utilized efficiently by ruminants fed low-quality forage without negatively affecting dry matter intake (DMI), organic matter (OM) digestibility, nitrogenuse efficiency, bacterial CP synthesis, or animal growth and reproductive performance (Bohnert et al., 2002a, b; Schauer et al., 2010; Van Emon et al., 2012). Atkinson et al. (2009) evaluated ruminal protein degradation and supplementation frequency (SF) on intake, nitrogen retention and nutrient flux across visceral tissues of lambs fed a low-quality forage diet. Diets evaluated contained either predominantly RDP or RUP, which were compared to a blended diet containing a 50:50 blend of RDP and RUP that was fed daily or on alternate days. Forage OM, neutral detergent fiber (NDF), acid detergent fiber (ADF), and nitrogen were unaffected by treatment, and neither protein degradability or SF had any effect on nitrogen retention.

Considering that in previous SF research cotton seed meal and soybean oil meal have been the source of supplemental protein, the present research objective was to evaluate substituting a significant amount of daily forage with either D or ALT-D feedings of a field pea-based blended RDP-RUP supplement containing 36% RUP to determine the effect on cow performance, pre-breeding estrous activity, reproductive performance, and calf performance. The study hypothesis was that ALT-D supplementation would be as effective as D supplementation and that the supplementation cost for hay replacement would not be expensive.

Materials and Methods

This adaptive field experiment was conducted at the North Dakota State University - Dickinson Research Extension Center (DREC) Ranch Headquarters (14º11'40"N 102º50'23"W) located thirty-five km north of Dickinson, ND, USA, in accordance with guidelines approved by the North Dakota State University Institutional Animal Care and Use Committee (Approval Number A10037).

To evaluate a drought mitigation management strategy for the substitution of a significant amount of daily forage fed to late gestation-early lactating beef cows, 107 multiparous (3-10 years old) range beef cows were randomly assigned in a 111 day study to the following three treatments: 1) all hay control diet ©, 2) 28% of forage dry matter (DM) replaced with a RDP-RUP blended field pea/co-product supplement (PEA-BMS-DDGS) fed D at the rate of 0.25% of initial cow body weight (BW); (D), and 3) 28% of forage DM replaced with a RDP-RUP blended PEA-BMS-DDGS supplement fed on ALT-D at the rate of 0.50% of initial cow BW (ALT-D). Each treatment group consisted of 4 pens (weight blocks: light, medium, medium-heavy, and heavy) with 9 cows per pen; 36 cows per treatment.

Diets fed were calculated to contain a balanced DM energy concentration across treatments using medium-quality alfalfa-bromegrass hay (*Medicago sativa* and *Bromus inermis*), spring wheat straw (*Triticum aestivum*), and a pelleted (0.635 cm) 22.8% CP PEA-BMS-DDGS supplement (Table 1). The amount of RDP and RUP supply in the supplement was determined according to the work of others (Bohnert et al., 2002a, b; Schauer et al., 2010; Van Emon et al., 2012) who have suggested that the quantity of RUP in a supplement be >20%. Additionally, it was important that the pelleted supplement have high pellet quality for feeding under range conditions. Feed formulations containing high levels of DDGS are difficult to pellet due to the high fiber content of DDGS. Previous research by Koch and Landblom (2010) has shown in formulations prepared with 60.0% DDGS that as the level of pea in the supplement formulations tested increased and the level of BMS decreased electricity consumption decreased and pellet quality increased. Therefore, based on this knowledge, the RDP-RUP supplement was formulated, as shown in Table 1, to contain 49.9% field pea, 22.0% BMS, and 20.0% DDGS. As analyzed, the supplement formulation provided 61.0% RDP and 36.0% RUP, and also had good pellet quality.

The unsupplemented C cow group received alfalfa-bromegrass hay only throughout the study. The D and Alt-D supplemented treatment groups were fed the alfalfa-bromegrass hay and spring wheat straw such that within a 7 day feeding period, alfalfa-bromegrass hay was fed 6 days and spring wheat straw was fed 1 day. The forages were delivered to the cows daily using a Haybuster® forage processor (Dura Tech Industries International, Inc., Jamestown, ND, USA 58401) equipped with a Digi-Star EZ 2000® electronic scale (Digi-Star, LLC, Fort Atkinson, WI, USA 53538).Forages were fed daily on the ground. Residual feed orts were collected weekly, weighed, and the DM content determined. The weekly forage ort DM was then deducted from the total DM fed to arrive at the pen dry matter intake (DMI).

During the 16 week study, daily DM fed within each weight block was determined based on the estimated energy content of the supplement, alfalfa-bromegrass hay, and spring wheat straw. To arrive at the desired calculated NEm energy balance across treatments, the initial DMI for each weight block was determined using the following Nutrient Requirements of Beef Cattle (NRC, 1996) DMI formula: DMI = (SBW$^{0.75}$ x (0.04997 x NE$_m$^{2} + 0.04361)/NE$_m$) (TEMP 1) (MUD 1) + 0.2 Yn), where SBW$^{0.75}$ is shrunk body weight (0.95 x BW, kg) and NEm of 1.35 Mcalkg^{-1}. In the DMI formula, net energy for maintenance of 1.0 Mcalkg^{-1} of diet was arbitrarily selected as the starting energy basis and milk production, Yn, was set at 1.23 kg, which was estimated to typify the milking ability of cows used in the experiment to balance energy across treatment weight blocks. In western North Dakota, USA, mud is rarely an issue; therefore, there was no adjustment for mud, which was set at 1.0. The initial late gestation

Table 1
Supplement composition and supplement and forage nutrient analysis

Supplement Composition[a]		Nutrient Analysis[b]			
Ingredient, DM %		Nutrient, DM %	Supplement	Hay	Straw
Field Pea	49.87	DM	90.28	84.9	84.4
Barley Malt Sprout (BMS)	22	CP	22.8	10.2	4.7
Distillers Dried Grain (DDGS)	20	ADF	10.52	39	49.2
Beet Molasses	5	NDF	27.74	57.6	77.06
Dicalcium Phosphate (21%)	2.45	TDN	79.08	52.5	35
Salt	0.5	Crude Fat	3.35	1.65	2
Trace Mineral Pre-Mix[c]	0.15	Fiber	8.36	32	41.7
Vitamin Pre-Mix[d]	0.025	Starch	29.62	8	-
		Ca^{2+}	0.63	0.93	0.27
		P	0.11	0.17	0.04
		NEm (Mcal kg^{1})	1.94	1.14	0.64
		NEg (Mcal kg^{1})	1.3	0.57	0.16
		RDP, %	61	80	30
		RUP, %	36	19.5	69

[a] Supplement: Pelleted with California Pellet Mill (CPM) (pellet size, 0.632 cm).
[b] Nutrient Analysis: Pea co-product supplement, alfalfa-bromegrass hay, spring wheat straw.
[c] Trace Mineral Pre-Mix Content kg-1: Potassium, 0.96%; Sodium, 0.42%; Chloride, 0.47%; Magnesium, 0.19%; Sulfur, 0.43%; Manganese, 161.28 mg kg^{-1}; Iron, 164.58 mg kg-1; Copper, 105.27 mg kg^{-1}; Zinc, 371.64 mg kg^{-1}; Cobalt, 1.82 mg kg^{-1}; Iodine, 8.84 mg kg^{-1}.
[d] Vitamin Pre-Mix Content: Vitamin E, IU 22.15; Vitamin A, IU 22.1533; Vitamin D3, IU 2.2153; Thiamine, 0.60 mg kg^{-1}.

daily NEmcow^{-1} for each starting weight block was calculated to be 10.10, 10.80, 11.67, and 12.52 Mcald^{-1} for the light, medium, medium-heavy, and heavy weight blocks, respectively. Since temperature fluctuations in western North Dakota can be extreme, the amount of forage DMI was adjusted at the beginning of each week for temperature based on the local weather forecast for the upcoming week. During the experiment, the average minimum temperature ranged from 2.0 to -15.1ºC and the average high ranged from 17.0 to -2.0ºC. Forage DM increases used, due to declining temperature, were as follows: 12.2ºC and above – no increase, 12.2ºC to -15.0ºC + 7% increase, -15.0ºC to -17.8ºC + 10% increase, -17.8ºC to -23.3ºC + 16% increase, and -23.3ºC to -28.9ºC + 20.0% increase (NRC 1996). These dietary adjustments were only applied to the amount of forage delivered to each BW block. The pelleted supplement was fed in 4.88 m x 0.76 m steel portable bunks and was delivered to the D and Alt-D supplemented treatment groups at 0830 each morning according the supplementation frequency protocol. During the entire study, the pelleted PEA-BMS-DDGS supplement level, which were established based on initial cow starting BW, did not change. Gestation diets were fed from the first week of January to the third week of March, when the diets were reformulated for lactation by removing spring wheat straw and increasing hay DMI. The daily lactation NEm balance for weight blocks was calculated to be 15.80, 18.19, 19.06, and 19.97 Mcald^{-1} for the light, medium, medium-heavy, and heavy weight blocks, respectively. The lactation diets were fed until the last week of April, when the cows and their calves were moved to crested wheatgrass (*Agropyron cristatum*) pastures.

The alfalfa-bromegrass hay and spring wheat straw bales fed were core sampled, composited weekly, and analyzed by a commercial laboratory for CP, neutral detergent fiber (NDF), acid detergent fiber (ADF), calcium (Ca^{2+}), and phosphorus (P), and total digestible nutrients (TDN) was estimated according to: TDN = 96.35 – (ADF % x 1.15); (AgSource Soil and Forage Laboratory, Bonduel, WI, USA); (Table 1). Before initiation of feeding, the experimental PEA-BMS-DDGS coproduct supplement was analyzed for CP, FAT, NDF, ADF, *in vitro* dry matter disappearance (IVDMD), *in vitro* organic matter disappearance (IVOMD), Ca^{2+}, and P at the North Dakota State University Nutrition Laboratory (Table 1). Samples were analyzed in duplicate according to the Association of Official Analytical Chemists (2010) for DM by drying at 135º C (AOAC method 930.15), CP (AOAC method 2001.11), ether extract (AOAC method 920.39), and Ca^{2+} and P (AOAC methods 968.08 and 965.17). Laboratory analysis for NDF and ADF were based on the procedure of Goering and Van Soest (1970), IVDMD and IVOMD analysis was based on the procedure of Tilley and Terry (1963).

Measurements of cow and subsequent calf performance included changes in cow BW, BCS, 12th rib fat thickness, the number of cows in estrus at the start of the breeding season, breeding cycle pregnancy rate, number of non-pregnant cows, and the total number of pregnant cows within treatment. Subsequent to the cow growth and breeding performance data, calf weaning performance data was evaluated. The average of two consecutive cow weights were taken at the start and end of the study. Coinciding with cow BW recording, the cows were scored for body condition (e.g., BCS: 1 = emaciated, 9 = obese; Wagner et al., 1988) at the start and end of the study with two evaluators, and fat thickness collectedbetween the 12thand 13th ribs was also measured at the start and end of the study using an Aloka 500 real-time ultrasound machine. The ultrasound machine was equipped with a 17 cm probe, standoff, PXC200 frame grabber, and UISC-USB-2820 Capture Technology (The National CUP Lab& Technology Center, Ames, Iowa, USA 50010).

Within 24 hours of birth, the calves were processed, which included recording of birth weight, navel iodine dip, and application of emasculator bands to bull calves. At seven weeks of age, the calves were vaccinated with One Shot Ultra® 7 for protection against blackleg caused by *Cl. chauvoei*, malignant edema caused by *Cl. septicum*, black disease caused by *Cl. novyi*, gas-gangrene caused by *Cl. sordellii*, and enterotoxemia and enteritis caused by *Cl. perfringens* types B, C, and D, and *Pasturella haemolytica* Type A1 (Zoetis 100 Campus Drive, Florham Park, NJ 07932).

The number of cows cycling at the start of a 45 day breeding season was based on circulating progesterone assay derived from serum recovered from two blood draws collected 10 days apart. Cows were considered to have returned to normal estrous cycling if one of the two serum assays had progesterone concentrations > 1 ng mL^{-1}, and were considered to be anestrous if both serum assays had progesterone concentrations < 1 ng mL^{-1}. Circulating concentrations of progesterone were analyzed in all serum samples using the methodology described by Engel et al. (2008). Intra- and interassay CV for progesterone assays were 2.47 and 5.9%.

Cows in the study were bred naturally using fertility tested bulls and the subsequent breeding cycle pregnancy rate, number of non-pregnant cows, and the total number of pregnant cows within treatment was determined using transrectal ultrasound cranial width measurements taken 30 days after the end of the 45 day breeding season using an Ausonics Impact VF1 ultrasound machine (Ausonics International Inc., 2860 De La Cruz Blvd., Santa Clara, CA USA 95050) and 6.0 MHz convex rectal probe (Universal Medical Systems, Inc., 299 Adams St., Bedford Hills, NY USA 10507).

At weaning, calves were weighed on two consecutive days and the mean weight was used for calf performance analysis that included calf birth weight, calf age at weaning, weaning BW, BW gain, and ADG.

Economic assessment of the nutrient mitigation strategies used in this study was evaluated using a 100 cow reference herd and local feed prices for forages and the pelleted supplement. Feed prices used in the evaluation were \$0.06164, \$0.2760, \$0.2756, and \$0.0133 for the mixed alfalfa-bromegrass hay, wheat straw, PEA-BMS-DDGS supplement, and supplement delivery to the farm, respectively. The assessment will identify the economic potential for the experimental supplement and SF to be economically viable forage shortage mitigation strategies.

The data was analyzed using the generalized least squares MIXED analysis procedure of SAS (Version 9.2; SAS Institute, Inc. Cary, NC). Main effects included dietary treatments (fixed) and pen (random) served as the experimental unit. Pre-trial cow gestation interval days were used as a covariate to adjust cow starting and ending weight, gain, and ADG. Sex of calf within treatment groups was evaluated as a covariate and was found to be not significant with respect to rebreeding performance in the investigation. Therefore, the covariate was removed from the model. Chi Square was used to analyze the subsequent reproduction data. Least square means were used to partition treatment effects and differences were considered significant at $P \leq 0.05$.

Results

According to the project objective, a drought nutrition management strategy was evaluated in which the amount of forage fed daily was reduced by 28.0% and replaced with a nutrient-dense PEA-BMS-DDGS supplement (Table 1) fed either D at 0.25% of initial BW or on Alt-D at 0.50% of initial BW. For the 111 d late gestation-early lactation period, C cows consumed an average 14.1 kg (DM basis) of alfalfa-bromegrass hay and the D and ALT-D day supplemented treatment cow groups consumed a combined average 10.13 kg of hay and spring wheat straw, which amounted to a forage intake reduction of 3.97 $kgcow^{-1}d^{-1}$($P < 0.001$) (Table 2). As a result, 1.0 kg of the pelleted PEA-BMS-DDGS co-product supplement replaced 2.90 kg of forage (e.g. alfalfa-bromegrass and spring wheat straw).

Cow performance was not negatively affected by forage reduction or SF (Table 3). Using pre-trial gestation interval as a covariate, cow starting weight, ending weight, and gain did not differ among treatments ($P>0.10$). Cow BCS changed from a prepartum starting condition of approximately 6 across treatments ($P>0.10$) to an ending postpartum BCS of 5.39, 5.47, and 5.14 for the C, D, and ALT-D treatments, respectively, that did not differ between treatments ($P>0.10$). Ultrasound fat thickness mimicked BCS and declined across treatments from the start of the study to the end, but there was no difference among treatments ($P>0.10$). Similarly, there was no difference ($P>.10$) between treatments in the percentage of cows that had initiated normal estrous cycles before the start of the breeding season.

Calf birth weight for calves whose dams received daily supplement were lighter ($P=0.014$) than calves from either C or ALT-D supplemented cows. Calf weaning weight ($P>0.10$) and pre-weaning gain did not differ ($P>0.10$).

Economic assessment of the forage mitigation strategies evaluated using the RDP-RUP blended PEA-BMS-DDGS supplement for 111 was conducted using a 100 cow reference herd (Table 4). Compared to the C cows in the assessment that consumed 156 510 kg of alfalfa-bromegrass hay, supplemented cows consumed 112 440 kg of hay and straw (e.g. 89 910 kg of alfalfa-bromegrass hay + 22 530 kg wheat straw) and an average 15 075 kg of supplement. Compared to the C treatment, the total cost for the D and ALT-D supplemented groups was 5.9 and 5.2% higher, respectively.

Discussion

Environmental conditions that reduce the amount of available forage on farms and ranches in the northern Great Plains of the USA can be offset using supplementation strategies that utilize nutrient-dense blended rumen degradable and undegradable protein supplements for forage substitution. The effective forage reduction of 28.1% (Table 2), which was substituted with 1.37 kg cow^{-1} $d^{-1}$of the blended RDP-RUP pelleted PEA-BMS-DDGS supplement, replaced a large quantity of hay and spring wheat straw without detrimental effect on post-calving animal performance or post-partum interval as measured by prebreeding estrus cycling activity (e.g. 70.4, 79.1, and 75.1% for the C, D, and ALT-D, respectively). The pregnancy cycle, percent of non-pregnant cows, and the total percent of cows pregnant in each treatment that did not differ ($P>0.10$).

Body condition score has been used extensively in the beef cattle industry as a tool to insure cows are in the best possible condition at the start of the breeding season (Houghton et al., 1990). Research has shown that body reserves at calving affect the postpartum interval (Wiltbank et al., 1961) and the interval from calving to first estrus and pregnancy rates are directly affected by cow BCS at calving and at breeding (Richards et al., 1986; Selk et al., 1988). Richards et al. (1986) evaluated BCS and suggested that a moderate body condition score of 5 (1 to 9 scale; Wagner et al., 1988) would be the most functional target BCS for mature beef cows at calving. Morrison et al. (1999) evaluated the effect on postpartum interval when low and high BCS cows were fed to either gain or lose BW to attain BCS of 5 at calving and concluded that large prepartum body reserve changes during the third trimester did not negatively affect reproductive performance. Ending BCS and estrus activity prior to the start of the breeding season clearly demonstrate that the substitution strategy employed effectively provided adequate nutrient flow to the fetus and the mother regardless of SF timing.

Although hay is the most common feed fed to gestating and lactating beef cows, the cost per unit of energy is often considerably more expensive than high energy feedstuffs such as corn (Loerch, 1996; Schoonmaker et al., 2003). Radunz et al. (2010) documented that energy source (e.g., grass hay, corn, or DDGS) fed during gestation did not affect pre- and postpartum cow performance, but energy partitioning associated with corn and DDGS shunted nutrients

Table 2
Forage and supplement intake, BCS, and cow-calf performance

	Treatments^{a}			
	Control	Daily	Alternate day	SEM^{b}
Number of Cows	35	36	36	
Forage Intake:				
Hay (cow-1d-1 kg)***	14.10a	8.10b	8.10b	0.34
Straw (cow-1d-1 kg)	-	2.03	2.03	-
Total forage (cow-1d-1 kg)***	14.10a	10.13b	10.13b	0.35
Supplement Intake:				
Supplement (cow^{-1} kg)*	-	152	149.5	7.85
Supplement (cow^{-1}d^{-1} kg)***	-	1.37	2.71	0.11
Cow Performance:				
Gestation Interval (d^{-1})*	197.8^{a}	198.7^{a}	195.3^{b}	1.23
Start BW ± SE, kg	651.3±33.09	654.9±33.13	665.7±33.17	
End BW ± SE, kg	610.7±21.84	595.5±23.87	643.7±25.66	
Gain BW ± SE, kg	-33.70±10.22	-40.22±10.88	-37.95±11.47	
ADG ± SE, kg	-0.2982±0.09	-0.3398±0.10	-0.3359±0.10	
Cow BCS				
Start	6.1	6	5.95	0.23
End	5.39	5.47	5.14	0.34
12th Rib Fat Thickness				
Start rib fat thickness, mm	6.42	6.31	6.53	0.67
End rib fat thickness, mm	3.97	4.92	4.67	0.74
Calf Performance:				
Birth BW, kg**	41.7^{a}	39.5^{b}	43.3^{a}	0.72
Weaning Age (d^{-1})*	213.9^{ab}	214.9^{a}	211.6^{b}	1.23
Weaning BW (cow^{-1}d^{-1} kg)	299.9	304.6	305.1	6.34
BW Gain, kg	258.2	265.1	261.9	6.31
ADG, kg	1.21	1.23	1.24	0.027

[a] Treatments: Control = All hay, Daily = Blended RDP/RUP Field Pea Co-product supplement fed daily at 0.25% of starting cow BW, Alternate Day = Blended RDP/RUP field pea co-product supplement fed on alternate days at twice the daily rate or 0.50% of starting cow BW

[b] Standard error of the mean

* Statistical significance at ($P < 0.05$).

** Statistical significance at ($P < 0.01$).

*** Statistical significance at ($P < 0.001$).

to the fetus and increased birth weight. In the present study, ending ultrasound fat depth did not differ; however, among the ALT-D and C hay groups calf birth weight was greater (P = 0.014) compared to the D supplemented group. Energy, CP, and amino acids are essential for late gestation fetal growth (Ferrell et al., 1976). Considering energy partitioning and nutrient shunting described by Radunz et al. (2010), and although the current data reported here is not conclusive, we hypothesize that there was greater lipid mobilization from fat stores among cows in the C and ALT-D groups combined with greater energy and N flow when the ALT-D supplemented cows received a double amount

Table 3
Reproductive performance

	Treatments[a]			
	Control	Daily	Alternate day	SEM[b]
Number of Cows	35	36	36	
Pre-Breeding Progesterone, Percent Cycling, %	70.35	79.06	75.06	6.85
Breeding Cycle Pregnancy Rate:				
1st Breeding cycle	43.9	63.5	53.5	6.28
2nd Breeding cycle	53	30.1	34.2	7.53
3rd Breeding cycle	3.1	3.6	8.7	4.39
Non-pregnant	0	2.8	3.6	2.61
Overall pregnancy	100	97.2	96.4	2.61

[a] Treatments: Control = All hay, Daily = Blended RDP/RUP Field Pea Co-product supplement fed daily at 0.25% of starting cow BW, Alternate Day = Blended RDP/RUP field pea co-product supplement fed on alternate days at twice the daily rate or 0.50% of starting cow BW

[b] Standard error of the mean

Table 4
Economic comparison of supplementation treatments using a 100 cow reference herd

	Treatments[a]		
	Control	Daily	Alternate day
Hay per cow, kg	1,565.10	899.1	899.1
Wheat straw per cow, Kg	-	225.3	225.3
Supplement per cow, Kg	-	152	149.5
Hay, straw and supplement for 100 cows			
Hay, kg	156,510	89,910	89,910
Wheat straw, kg	-	22,530	22,530
Supplement, kg	-	15,200	14,950
Hay, straw and supplement cost for 100 cows			
Hay, $[b]	10,351.57	5,946.65	5,946.65
Wheat Straw, $[c]	-	621.83	621.83
Supplement, $[d]	-	4,391.28	4,319.06
Total Cost	10,351.57	10,959.76	10,887.53
Difference Compared to CON		608.18	535.96
Percent difference compared to CON		5.9	5.2

[a] Treatments: Control = All hay, Daily = Blended RDP/RUP Field Pea Co-product supplement fed daily at 0.25% of starting cow BW, Alternate Day = Blended RDP/RUP field pea co-product supplement fed on alternate days at twice the daily rate or 0.50% of starting cow BW

[b] Hay cost per kg = $0.06614

[c] Wheat straw cost per kg = $0.0276

[d] Supplement cost per kg = $0.2889

of supplement resulting in greater calf birth weight, which may be associated with feeding excess nutrients on the days of supplementation.

A moderate BCS of 5 at calving is considered to be the single most important factor associated with subsequent rebreeding efficiency among mature cows. Supplementation frequency using the field pea-based supplement did not cause digestive upset (bloat or acidosis) when fed on alternate days and supported an ending postpartum BCS greater than 5 resulting in cows that were adequately prepared for the ensuing breeding season. The research results reported here suggest that substituting 28.1% of the forage fed with a nutrient-dense pelleted PEA-BMS-DDGS supplement formulated to contain a blend of RDP (61.0%) and RUP (36.0%), and fed on Alt-D, maintained nitrogen balance and efficiency supplying protein and energy to pre- and postpartum cows fed restricted hay and spring wheat straw diets. The production results of this research are in agreement with others (Bohnert et al., 2002a, b; Atkinson et al., 2009; Schauer et al., 2010; Van Emon et al., 2012) who have collectively reported that crude protein supplements consisting of RUP greater than 20% can be utilized without affecting DMI, OM digestibility, bacterial crude protein synthesis, and maintenance of nitrogen use efficiency resulting in animal and reproductive performance that is comparable to full fed animals.

Assessment of the economies comparing forage sparing mitigation strategies, evaluated in this study, ended with a very comparable feed cost outcome, which was supportive for the use of a RDP-RUP blend prepared from highly digestible co-product ingredient sources. The cost per cow for the 111 day period was $287.54, $304.44, and $302.43 for the CON, D, and ALT-D, respectively. The hay CON treatment was the lowest cost. However, when emergency measures must be taken to avoid selling cows, the sup contributing to the positive animal response to supplementation and similar treatment cost was the low ADF (10.52%) and NDF (27.74%) values and high supplement TDN (79.1%) value. Since bloat and acidosis can be a problem in supplementation strategies that include ALT-D or longer periods between supplement feedings the number of supplement options becomes limited to ingredients like soybean and cottonseed meals. Compared to soybean meal the cost per unit of protein for the PEA-BMS-DDGS supplement was $0.08 cents higher ($1.21 versus $1.13/ kg). This narrow margin between supplements on a cost per unit of protein basis makes the experimental supplement competitively priced. Beef cattle producers that adopt the hay shortage mitigation strategy defined in this study using ALT-D feeding can take advantage of a competitively priced alternative while experiencing good cow performance and reducing labor.

Conclusions

Several consequences were identified after the nutrition of a 28.1% hay reduction was replaced with a combination of wheat straw and a 22.8% CP PEA-BMS-DDGS supplement. While maintaining dietary nutrient balance across treatments, replacing hay with straw and the PEA-BMS-DDGS supplement did not affect cow performance as evidenced by the fact that there was no difference measured between treatments for ending cow weight, BCS, fat thickness, the percentage of cows that returned to estrous cyclicity by the start of the breeding season, first, second and third breeding cycle pregnancy rate, the percentage of non-pregnant cows, and the total percentage of pregnant cows at the end of the study. Secondly, there was no difference between treatments for D or ALT-D supplementation. Although in this research, we did not directly measure blood urea nitrogen, others have (Bohnert et al., 2002a, b; Schauer et al., 2010; Van Emon et al., 2012; Atkinson et al., 2009) and based on their results, our data suggests that nutrient recycling provided adequate nitrogen to the rumen on the non-supplementation day. Thirdly, ALT-D supplementation may be the basis for increased calf birth weight, although dystocia was not an issue in the ALT-D treatment of this study, and fourthly, there was no difference in calf weaning weight at the end of the study.

Economic assessment for replacing hay with a combination of wheat straw and a 22.8% CP PEA-BMS-DDGS supplement indicated that the cost was only slightly more expensive than feeding an all hay diet. Since the biological animal response and economic assessment were both positive for using a combination of wheat straw and the experimental supplement, cattle producers faced with hay shortages due to limited growing season precipitation are encouraged to consider the results of this research project in which 1.0 kg of supplement replaced 2.9 kg of forage.

More research is needed. Supplementation frequency evaluated in this study only looked at ALT-D feeding using aPEA-BMS-DDGS supplement; however, three questions remain: 1) can SF interval using aPEA-BMS-DDGS supplement be extended, 2) due to urea nitrogen recycling, what is the appropriate quantity of supplement to be fed when the supplementation interval is extended to 3, 4, or even 5 days, and 3) when larger quantities of supplement containing field pea are fed, will larger quantities of field pea inclusion invoke digestive problems? These are important questions that need further investigation.

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