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INCREASING GLUCOGENIC PRECURSORS IN RANGE SUPPLEMENTS FED TO YOUNG POSTPARTUM BEEF COWS SHORTENS POSTPARTUM INTERVAL

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ABSTRACT: Cattle grazing winter range forage often exhibit yearly variation in response to supplementation. This variation may be predisposed by circulating concentration and subsequent metabolism of glucose, whieh is influenced by the quality and availability of dormant range forage. Therefore, a study conducted at the Corona Range and Livestock Research Center during two dry years, 2000 (driest) and 2001, evaluated the responses of supplements differing in glucogenic precursors fed to young postpartum beef cows. Supplements were fed at 908 g•cow^{-1}•d^{-1} twice weekly for approximately 95 d postpartum and provided 327 g CP, 118 g UIP (LOGLUC); 327 g CP, 158 g UIP (MIDGLUC); or 327 g CP, 164 g UIP + 100 g propionate salt (HIGLUC; NutroCal™, Kemin Industries, Inc.). Days to postpartum BW nadir were similar ($P = 0.56$) for both years among supplemented cows (46, 51, and 48 ± 3 d for LOGLUC, MIDGLUC, and HIGLUC, respectively). A supplement x year interaction was observed for average daily gains from BW nadir to the end of supplementation ($P = 0.05$; 0.27, 0.41, and 0.49 ± 0.11 kg•d^{-1} in yr 1 and 1.04, 1.07, and 0.90 ± 0.07 kg•d^{-1} in yr 2 for LOGLUC, MIDGLUC, and HIGLUC, respectively). Adjusted weaning weights for calves were lighter by approximately 16 % in yr 1 compared to yr 2 ($P < 0.01$; 161 ± 1.9 vs. 19.7 ± 2.1 kg, for yr 1 and yr 2, respeetively). These results emphasize yearly variations encountered in response to supplementation and suggests that alterations in nutrient partitioning occurs depending on availability of circulating glucose and quality of dormant range forage.

Keywords: Glucose, Propionate, Protein Supplements

Introduction

Protein has been shown to be a primary limiting nutrient in diets consumed by cows grazing mature vegetation (Krysl et al., 1987), and protein supplementation can enhance intake and digestibility of dormant range forage (Owens et al., 1991). Feeding undegradable intake protein (UIP) once degradable intake protein (DIP) requirements are satisfied (NRC, 1996), can repartition nutrients away from nutrient sinks (i.e., lactation) and toward tissue growth (Hunter and Magner, 1988; Miner et al., 1990; Wiley et al., 1991). However, understanding the role of glucose utilization and efficiency of glucose incorporation into tissues of range cows may provide insight into their metabolism. Waterman et al., (2000) indicates that supplements containing additional glucogenic precursors may enhance glucose uptake and utilization by stimulating insulin sensitivity. As glucogenic potential increased in protein supplements, glucose half-life was reduced demonstrating improvements in insulin sensitivity (Waterman et al., 2002).

Therefore, the objective of this research was to evaluate production responses by 2-yr-old postpartum beef cows to supplements varying in glucogenic precursors supplied by protein or propionate salt.

Material and Methods

A 2 yr study was conducted at New Mexico State University's Corona Range and Livestock Research Center, Corona, NM during late winter and spring of 2000 and 2001. The Corona Range and Livestock Research Center is located 300 km northeast of Las Cruces, NM (average elevation = 1900 m; average annual precipitation = 400 mm; Figure 1). Predominant grasses in grazed pastures include blue grama (*Bouteloua gracilis*) and wolftail (*Lycurus phleoides*); however, other less dominant grasses and forbs are present (Knox, 1998). Diet extrusa samples were collected as cows changed pastures (initiation of supplementation and prior to breeding) for analysis of CP and NDF (AOAC, 1990; Table 1) using two ruminally cannulated cows.

A total of 51 (yr 1) and 36 (yr 2) 2-yr-old cows were used in this study, predominantly comprised of Angus with varying genetic influences of Hereford and Simmental breeding. At calving, calf weights were recorded and cow/calf pairs were moved into a common pasture and managed as one herd for the duration of the study. A 60-d breeding season was initiated with bulls and cows introduced into a new pasture at the beginning of May in both years (125 and 124 Julian dates for yr 1 and yr 2, respectively; Figure 2).

Supplemental feeding began approximately 10 d postpartum with animals being assigned to treatment by calving date. Cows were gathered from the pasture twice weekly and individually fed supplement for approximately 90-d (yr 1) and 100-d (yr 2; Figure 2), which included the first 36-d (yr 1) and 31-d (yr 2) of the breeding seasons. Three supplements were formulated on an as fed basis to be isoenergetic and sufficient in ruminally degradable protein. Each supplement differed in regards to concentration of glucose precursors or glucogenic potential (GP).

Supplements were fed at a rate of 908 g•cow^{-1}•d^{-1} to provide 327 g CP, 118 g UIP, 47.3 g GP (LOGLUC); 327 g CP, 175 g UIP, 63.0 g GP (MIDGLUC); or 327 g CP, 180 g UIP + 100 g propionate salt, 143.7 g GP (HIGLUC; NutroCal™, Kemin Industries, Inc.). Glucogenic potential was calculated on the basis that 40% of UIP supplied can be rendered glucogenic as described by Preston and Leng (1987), and that propionate salt is approximately 100% g.

Cow BW were obtained every 2 weeks following supplementation until the termination of the breeding season. Days to BW nadir were determined from lowest BW obtained postpartum from weights taken twice weekly. Intervals were constructed to evaluate ADG from BW nadir at pre-specified times within the study. Average daily gains were determined for each cow from precalving BW to BW nadir, BW nadir to the end of breeding, BW nadir to the end of supplementation, and end of supplementation to the end of breeding. Calves were weighed at weaning and weights were adjusted to a 205-d weaning weight. Beginning approximately 55-d postpartum, serum samples were collected weekly (Friday; yr 1) and twice weekly (Monday and Friday; yr 2) via coccygeal venipuncture for progesterone (P_4) concentration to determine days to first luteal activity (P_4 ≈ 1 ng/mL) and days to first estrus (2 or more consecutive P_4 concentrations ≥ 1 ng/mL). Samples assayed for P_4 were analyzed by solid phase RIA (Coat-A-Count; Diagnostic Products Corp., Los Angeles, CA) as described by Schneider and Hallford (1996).

Cows from each treatment (n = 8, yr 1; n = 12, yr 2) were gathered and individually milked the day following supplementation (yr 1) and two consecutive days following supplementation (yr 2; 6•cows•trt^{-1}•d^{-1}), at approximately 57-d postpartum. Milk production estimates were measured as previously described by Appeddu et al. (1997). Milk samples were analyzed for protein, lactose, butterfat, and solids non-fat by Pioneer Dairy Labs, DHIA (Artesia, NM).

Data were analyzed as a completely randomized design by analysis of variance using GLM procedures of SAS (SAS Inst. Inc., Cary, NC) with cow as the experimental unit. Continuous variables were analyzed as a 2 x 3 factorial arrangement using the main effects of supplement, yr, and their interaction in the model. Covariates were used when appropriate and included calving date, days on feed, and precalving weight taken on January 12, 2000 (yr 1) and January 4, 2001 (yr 2). Two pre-planned contrasts were used to separate least square treatment means when no supplement x year interactions were detected: 1) LOGLUC vs. HIGLUC to compare supplements differing in UIP and addition of 100 g propionate salt; 2) MIDGLUC vs. HIGLUC to evaluate supplements differing only by an additional 100 g of propionate salt. Categorical data (i.e., % pregnancy) were analyzed using the CATMOD procedure of SAS (SAS Inst. Inc., Cary, NC).

Results and Discussion

Postpartum beef cows grazing dormant winter range often exhibit substantial BW loss immediately following parturition (Appeddu et al., 1997). Body weight nadir describes the extent or magnitude of weight loss when postpartum cows experience negative energy balance. This study was conducted during consecutive drought years, which increased nutritional stress. Nutritional quality of range forage improved as season progressed in both years, and overall quality was greater in yr 2 (Table 1). Improvements observed for yr 2 were influenced by early spring moisture (Figure 1) and an influx of annual forbs.

Days from calving to BW nadir (approximately 48-d) were similar for all supplemented cows (Table 2); however, BW losses (kg/d) were influenced by yr with cows in yr 1 losing weight faster ($P < 0.01$; Table 3). A significant yr effect ($P < 0.01$) was also observed for ADG from end of supplementation to end of breeding with cows in yr 2 exhibiting higher rates of gain due to increased forage quality (Table 3).

Cows fed HIGLUC had greater ADG from end of supplementation to the end of breeding (Table 2). Waterman et al. (2002) reported that 2-yr-old cows fed the HIGLUC supplement responded to a glucose challenge with a reduced glucose half-life ($P < 0.05$). This strongly indicates they were more sensitive to insulin (Kaneko, 1989).

We propose that as forage quality changed (Table 1), cows fed the HIGLUC supplement were predisposed to gain BW faster due to their rapid ability to clear glucose (Waterman et al., 2002). In order for animals to gain weight they must secrete insulin and respond to it. Animals fed propionate salt are more sensitive to insulin (Waterman et al., 2002). They partition more of the high quality nutrients from late spring forage into BW gain rather than milk. This improvement in insulin sensitivity carries beyond the end of supplementation, allowing for the partitioning effect of nutrients.

A supplement x year interaction ($P \leq 0.05$) was detected for average daily gains from BW nadir to end of supplementation and from BW nadir to end of breeding, which indicates that cows respond differently to supplementation depending on quality of available forage (Table 4).

Adjusted 205-d weaning weights were greater ($P = 0.08$) for calves from cows supplemented with MIDGLUC (Table 2). On average, weaning weights were approximately 50 kg lighter than what had been previously reported from cows grazing the same pastures and receiving similar supplements (Sawyer et al., 2000). Adjusted weaning weights were approximately 16% heavier in yr 2 compared with yr 1 (Table 3). The lower weaning weights observed in yr 1 were probably influenced by drought conditions, changes in milk production, and lack of nutrient-dense forage.

Trends observed in calf weaning weights reflected cow milk production. Milk production was numerically greater for cows receiving MIDGLUC supplement. These data agree with findings of others that UIP supplemented cows produce more milk (Appeddu et al., 1997; Sawyer et al., 2000). Cows receiving MIDGLUC secreted more ($P = 0.02$) butterfat than either the LOGLUC or HIGLUC supplemented cows (Table 2). The lower butterfat secretion in milk of the HIGLUC supplemented cows compared with MIDGLUC-fed animals is indicative of greater insulin sensitivity, which acts to partition nutrients away from milk production. These 2 groups of cows were fed identical supplement differing only in 100 g of propionate salt incorporated into the HIGLUC supplement. Year effects were evident for milk production ($P = 0.08$) and all constituents ($P < 0.12$; Table 3).

An important outcome of nutrient partitioning due to improved insulin sensitivity by postpartum cows would be improved reproduction. The number of days between calving and first luteal activity were similar ($P = 0.29$) for all supplemented cows (Table 2). However, luteal activity was delayed in yr 2 ($P < 0.01$) even though cow gains were greater (Table 3). This may have been influenced by the increase in milk production observed in yr 2 (Table 3). Days from calving to first estrus were reduced ($P = 0.03$) in HIGLUC supplemented cows by 9 d compared with LOGLUC fed cows (Table 2). Greater ADG from end of supplementation to end of breeding and lower milk fat production suggest a mechanism for shortening postpartum interval. By adding propionate salt in combination with UIP, nutrient partitioning shifted away from milk production and towards tissues and reproduction. Overall pregnancy rates for supplemented cows were not influenced by supplement ($P = 0.78$; Table 2), or yr ($P = 0.54$; Table 3).

Cost of supplementing postpartum cows with varying levels of glucogenic precursors will depend on availability, source, and amount of glucogenic precursors incorporated into the supplement ($21.58, 21.32, and 38.58•cow for LOGLUC, MIDGLUC, and HIGLUC, respectively).

Cows receiving HIGLUC supplements responded consistently in three of our measurements in both years. They secreted less butterfat compared with their herd mates fed MIDGLUC supplement. This response indicates that nutrients were diverted away from milk production probably due to improved insulin sensitivity demonstrated by Waterman et al. (2002). Improved insulin sensitivity allowed for greater gains between end of supplementation and end of breeding in HIGLUC supplemented cows when range forage quality had improved. These two results led to a physiological condition allowing HIGLUC supplemented cows to achieve estrus 9-d earlier than the LOGLUC fed cows.

Implications

As glucogenic precursors increased in supplemental treatments there were improvements in average daily gain, milk production, and days to first estrus. Reduction in postpartum interval for supplemented cows receiving the highest amount of glucogenic precursors increases the likelihood for calves to be born sooner in subsequent years.

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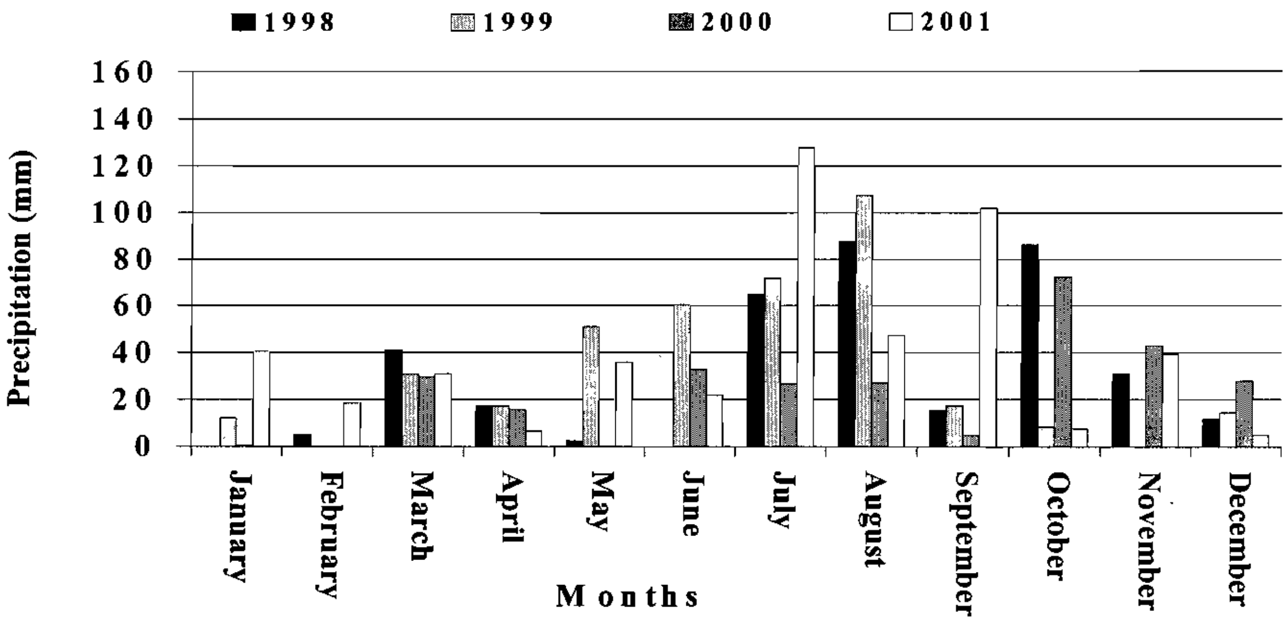

Figure 1. Monthly precipitation of pastures grazed by 2-yr-old post partum beef cows from January through July for four consecutive years (2 year prior to study (1998-1999) and 2 year during study (2000-2001)). Annual precipitation was 363, 391, 280, and 483 mm for 1998, 1999, 2000, and 2001, respectively.

Item	Year 1	Year 2
Start of calving	33	16
Start of supplementation	73	55
End of calving	78	64
Milking	106	104 & 105
Start of breeding	125	124
End of supplementation	161	155
End of breeding	189	187
Weaning	275	247

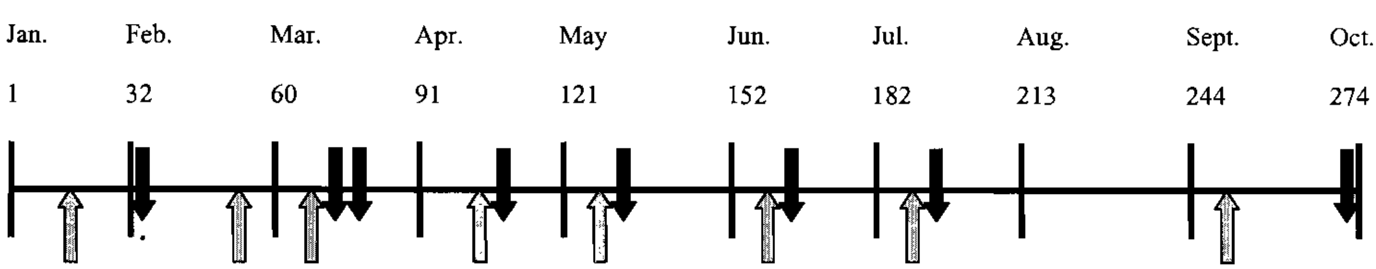

Figure 2. Timeline by month and Julian date for specific events throughout year 1 (2000) and year 2 (2001) of study.

Table 1. Ruminal extrusa analysis for CP and NDF (% OM), at the beginning of supplementation and beginning of breeding from pastures grazed by 2-yr-old postpartum cows in Year 1 and Year 2 (2000 and 2001, respectively).

Item	Analysis Time	
	Begin Supplement	Begin Breeding
Year 1		
CP (%)	4.2	7.4
NDF (%)	59.3	61.1
Year 2		
CP (%)	5.8	9.6
NDF (%)	54.0	53.0

Table 2. Supplement effects on magnitude of BW nadir (days to lowest body weight post calving) and average daily gain (kg/d) from precalving body weight until body weight nadir (Precalving BW-BW Nadir), end of supplementation to the end of breeding, adjusted 205-d weaning weights of calves, milk production and constituents, and reproductive parameters for 2-yr-old postpartum cows fed supplements differing in glucogenic precursors with or without propionate salt.

Item[c]	Supplement[a]				Contrast[b]	
	LOGLUC	MIDGLUC	HIGLUC	P-value	1	2
Weight						
Days to BW Nadir, d	46 ± 3	51 ± 3	48 ± 3	0.46	0.52	0.65
Precalving BW-BW Nadir, kg/d	-1.99 ± 0.21	-1.94 ± 0.21	-2.01 ± 0.21	0.96	0.86	0.96
End Supplementation-End Breeding, kg/d	0.77 ± 0.10	0.73 ± 0.10	1.10 ± 0.15	0.02	0.03	0.01
Weaning Weight						
Adj. WW, kg	175 ± 2.4	182 ± 2.4	175 ± 2.4	0.08	0.83	0.19
Milk, g/d						
24 h milk production	5477.03 ± 380.66	6494.65 ± 380.1	5974.12 ± 395.31	0.18	0.38	0.38
Protein	146.82 ± 11.32	169.56 ± 11.31	157.78 ± 11.79	0.37	0.51	0.47
Lactose	276.82 ± 18.84	327.31 ± 18.82	297.37 ± 19.57	0.17	0.46	0.29
Butterfat[b]	206.52 ± 20.39	287.56 ± 20.56	230.71 ± 21.17	0.02	0.52	0.06
Solids non-fat	466.19 ± 33.70	555.21 ± 33.65	508.89 ± 35.00	0.19	0.41	0.36
Reproductive Parameters						
Days to first luteal activity	99 ± 2	95 ± 2	95 ± 2	0.29	0.27	0.80
Days to first estrus	119 ± 3	114 ± 3	110 ± 3	0.09	0.03	0.35
Pregnancy rate	82.76 (24/29)	86.21 (25/29)	79.31 (23/29)	.78	NA	NA

[a]LOGLUC = 327g CP, 118g UIP, MIDGLUC = 360g CP, 175g UIP, HIGLUC = 360g CP, 180g UIP + 100 g propionate salt.
[b]Contrasts for supplement. 1 = LOGLUC vs. HIGLUC; 2 = MIDGLUC vs. HIGLUC.
[c]No supplement x yr interaction; P > 0.05.

Table 3. Yearly effects on magnitude of BW nadir (days to lowest body weight post calving) and average daily gain (kg/d) from precalving body weight until BW nadir (Precalving BW-BW Nadir), end of supplementation to the end of breeding, end of breeding to weaning, adjusted 205 d weaning weights of calves, milk production and constituent excretion, and reproductive parameters for 2-yr-old postpartum cows fed supplements differing in glucogenic precursors with or without propionate salt in Year 1 and Year 2 (2000 and 2001, respectively).

	Year		
Item[a]	2000	2001	P-value
Weight			
Day to BW Nadir, d	46 ± 3	50 ± 3	0.17
Precalving BW-BW Nadir, kg/d	-2.82 ± 0.27	-1.13 ± 0.21	< 0.01
End Supplementation-End Breeding, kg/d	0.59 ± 0.08	1.15 ± 0.09	< 0.01
Weaning Weight			
Adj. WW	161 ± 1.9	193 ± 2.1	< 0.01
Milk			
24 h milk production	5581.04 ± 347.61	6382.83 ± 277.19	0.08
Protein	139.41 ± 10.34	176.70 ± 8.25	< 0.01
Lactose	282.85 ± 17.21	318.15 ± 13.72	0.12
Butterfat[b]	204.17 ± 1.86	193.66 ± 2.08	< 0.01
Solids non-fat	467.96 ± 30.77	552.24 ± 24.54	0.04
Reproductive Parameters			
Days to first luteal activity	82 ± 2	112 ± 2	< 0.01
Days to first estrus	112 ± 2	117 ± 2	0.14
Pregnancy rate	82.35 (42/51)	83.33 (30/36)	0.54

[a]No supplement x yr interaction; $P > 0.05$.

Table 4. Average daily gain (kg/d) from body weight nadir until end of supplementation (BW Nadir-End Supplementation) and body weight nadir until the end of breeding (BW Nadir-End Breeding) for 2-yr-old postpartum cows fed supplements differing in glucogenic precursors with or without propionate salt in Year 1 and Year 2 (2000 and 2001, respectively).

	Supplement[a]			
Item	LOGLUC	MIDGLUC	HIGLUC	P-value
Year 1[b]				
BW Nadir-End Supplementation, kg/d	0.27 ± 0.10	0.41 ± 0.10	0.49 ± 0.11	0.05
BW Nadir-End Breeding, kg/d	0.31 ± 0.06	0.38 ± 0.06	0.56 ± 0.07	0.01
Year 2[b]				
BW Nadir-End Supplementation, kg/d	1.07 ± 0.11	1.04 ± 0.11	0.75 ± 0.11	0.05
BW Nadir-End Breeding, kg/d	1.04 ± 0.07	1.07 ± 0.07	0.90 ± 0.07	0.01

[a]LOGLUC = 327g CP, 118g UIP, MIDGLUC = 360g CP, 175g UIP, HIGLUC = 360g CP, 180g UIP + 100 g propionate salt.
[b]Supplement x yr interaction; $P \leq 0.05$.