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INCREASING GLUCOGENIC PRECURSORS IN RANGE SUPPLEMENTS ALTERS NUTRIENT PARTITIONING IN YOUNG POSTPARTUM RANGE COWS

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ABSTRACT: Altering nutrient partitioning in young postpartum beef cows from milk production to body weight gain has potential to improve reproductive performance. A 2-yr study conducted at the Corona Range and Livestock Research Center from February to July in 2003 (n = 51) and 2004 (n = 40) evaluated responses of 2- and 3-yr-old postpartum beef cows grazing dormant native range to three protein supplements with increasing glucogenic potential (**GP**). Supplements were fed at 1135 $g \cdot cow^{-1} \cdot d^{-1}$ twice weekly for approximately 70 d and provided 1) 341 g CP, 142 g UIP, 57 g GP (**UIP0**), 2) 341 g CP, 151 g UIP + 80 g propionate salt (NutroCAL™, Kemin Industries, Inc.), 124 g GP (**UIP80**), or 3) 341 g CP, 159 g UIP + 160 g propionate salt, 192 g GP (**UIP160**). A supplement × yr × age interaction was observed for days to first estrus (P = 0.04). Cows fed UIP0 took longer to return to estrus in 2004 than in 2003, with 2-yr-old cows requiring more days than 3-yr-old cows in 2004. The yr difference may be due to pastures receiving less precipitation during the previous growing season in 2004 than 2003, differences in diet quality and/or diet species composition between the two years, or some combination of these factors. Weight loss was greater from start of supplementation to BW nadir in 2004 (P < 0.01; – 12 vs – 49 ± 3 kg for 2003 and 2004, respectively). Milk production exhibited a quadratic (P < 0.01) response to increasing glucogenic precursor content in the supplement with cows fed UIP80 producing the least amount of milk (8278, 7257, and 8684 ± 358 g/d for UIP0, UIP80, and UIP160, respectively). Implications of this study suggest that cows fed the moderate level of GP partitioned nutrients away from milk production and towards reproduction.

Key words: Propionate, Protein Supplements, Reproduction

Introduction

One of the biggest challenges facing range cow/calf producers is poor breed back of 2- and 3-year-old cows. Lack of dietary glucogenic precursors is one of the many factors influencing return to estrus and subsequent conception in young beef cows. In ruminants, nearly 100% of glucose needs are synthesized from products of digestion, including propionate and amino acids. However, high-acetate ruminal fermentation of dormant range yields small and probably inadequate quantities of these precursors, particularly propionate. To add to the deficit of glucose available to the postpartum cow, the glucose requirement has increased dramatically due to the nutrient demands of lactation. Glucose precursors enhance gluconeogenesis, thereby influencing nutrient partitioning by altering tissue sensitivity to nutrients. Waterman et al. (2002b) found cows fed range protein supplement containing glucogenic precursors in the form of 100 g/d of propionate salt returned to estrus 9 d earlier than cows fed a traditional cottonseed meal-based supplement with no additional glucogenic precursors. The objective of the current research was to investigate if 2- and 3-yr-old postpartum cows would benefit if the amount of glucogenic precursors in the supplements was increased. To accomplish this objective, we evaluated return to estrus, milk production, weight change responses, and insulin sensitivity of postpartum 2- and 3-year-old range beef cows to supplements with increasing glucogenic potential (**GP**) provided as 0, 80, or 160 g/d propionate salt.

Materials and Methods

A 2-yr study was conducted at the Corona Range and Livestock Research Center, Corona, NM during late winter and spring of 2003 and 2004. The Corona Range and Livestock Research Center (average elevation = 1900 m; average annual precipitation = 400 mm) is located 300 km northeast of Las Cruces, NM. Predominant forages in experimental pastures included blue grama (*Bouteloua gracilis*) and wolftail (*Lycurus phleoides*), as well as other less dominant grasses and forbs (Forbes and Allred, 2001). Each year, three ruminally cannulated cows were used to collect diet samples for analysis of CP (AOAC, 2000) and NDF (Van Soest et al., 1991). In 2003, CP and NDF concentrations (OM basis) averaged 15.4% and 81%, respectively. In 2004, CP and NDF concentrations (OM basis) averaged 11.3% and 80%, respectively.

All animal handling and experimental procedures were conducted in accordance with guidelines of the Institutional Animal Care and Use Committee of New Mexico State University. Cows (n = 91 total; n = 51 in 2003; n = 40 in 2004) were two (n = 33) and three (n = 58) yr of age and predominantly Angus with some Hereford and Simmental influence. Cows were assigned to treatment by calving date so that similar d postpartum were reflected in each treatment group. Supplements were individually fed at a rate of 1135 $g \cdot cow^{-1} \cdot d^{-1}$ for avg 69 d postpartum. In 2003, supplementation continued through the first 21 d of breeding season (6 June); in 2004, supplementation ceased when breeding season began (15 May). Supplements provided 1) 341 g CP, 142 g UIP, 57 g GP (**UIP0**), 2) 341 g CP, 151 g UIP + 80 g propionate salt (NutroCAL™, Kemin

Industries, Inc.), 124 g GP (**UIP80**), or 3) 341 g CP, 159 g UIP + 160 g propionate salt, 192 g GP (**UIP160**). Glucogenic potential was calculated by the equation of Preston and Leng (1987), where 40% of the undegraded intake protein is considered glucogenic. NutroCAL™ contains 80% propionate, which was assumed to be 100% glucogenic.

Blood samples were collected twice weekly on supplementation days (Monday and Friday) via coccygeal venipuncture beginning approximately 40 d postpartum for analysis of progesterone to determine d to first estrus (2 or more consecutive progesterone concentrations > 1 ng/mL). Samples were analyzed for progesterone by solid-phase radioimmunoassay (Coat-A-Count, Diagnostic Products Corp., Los Angeles, CA) as described by Schneider and Hallford (1996). Inter- and intra-assay coefficients of variation were less than 10%. Cows were diagnosed for pregnancy via rectal palpation at weaning (26 September 2003; 24 September 2004).

A subsample of cows (n = 29 in 2003; n = 20 in 2004) were milked with a portable milking machine approximately 57 d postpartum on a d following supplementation using a modified weigh-suckle-weigh technique (Appeddu et al., 1997). Milk weight was recorded to estimate milk yield. Milk subsamples were collected in preservative-coated vials for analysis of protein, lactose, butterfat, and solids non-fat by an independent laboratory (Pioneer Dairy Labs, DHIA, Artesia, NM).

Cows were weighed weekly until termination of breeding season and at weaning. Days to BW nadir were determined from lowest BW obtained postpartum. Pre-planned intervals of weight change were calculated and included beginning of supplementation to BW nadir, BW nadir to end of supplementation, BW nadir to end of breeding, and end of supplementation to end of breeding. Body condition scores (**BCS**; 1 = emaciated, 9 = obese) were assigned to each cow by visual observation and palpation at beginning and end of supplementation, beginning and end of breeding season, and at weaning. Calf birth weights were obtained in the field within 3 d after birth with a portable platform scale. Calves were weighed at weaning and adjusted 205-d weaning weights were used as a measure of calf growth; no adjustment was made for sex of calf or age of dam in the calculation.

A glucose tolerance test (**GTT**) was conducted approximately 53 d (2003) or 65 d (2004) postpartum on a subsample of cows (n = 26 in 2003; n = 20 in 2004) on a day after supplementation. A 50% dextrose solution was infused at 0.5 mL/kg BW via indwelling jugular catheter inserted the morning of the GTT. Blood samples were collected at –1, 0, 3, 6, 9, 12, 15, 20, 40, 60, 80, 100, 120, 140, 160, and 180 min relative to infusion. Glucose was analyzed with a commercial kit ([Trinder] method, Sigma Diagnostics, St. Louis, MO or enzymatic endpoint method, Thermo DMA, Louisville, CO). Insulin was analyzed by solid-phase radioimmunoassay (DCP kit, Diagnostic Products Corp., Los Angeles, CA) as validated by Reimers et al. (1982). Intra- and inter-assay coefficients of variation were less than 10%. Serum glucose and insulin areas under the curve (AUC) were calculated using trapezoidal summation. Glucose half-life was estimated by determining time required for 50% decrease in peak serum glucose concentration.

Data were analyzed as a completely randomized design by analysis of variance using GLM procedure of SAS (SAS Inst., Inc., Cary, NC) with cow as experimental unit. The effects of supplement, year, cow age and their interactions were used in the model. Covariates were used when appropriate and included calf gender, calving date and days on feed. When appropriate, orthogonal polynomial contrasts were used to test for linear and quadratic effects of increasing supplemental glucogenic precursors. Pregnancy data were analyzed using GENMOD procedure of SAS (SAS Inst., Inc., Cary, NC).

Results and Discussion

A supplement × yr × age interaction was observed for d to first estrus (P = 0.04, Table 1). Return to estrus occurred later in cows fed UIP0 in 2004 than 2003, with 2-yr-old cows requiring more d than 3-yr-old cows in 2004. The yr difference may be due to pastures receiving less precipitation during the previous growing season in 2004 than 2003 (Figure 1), differences in diet quality and/or diet species composition between the two years, or some combination of these factors. More UIP0- and UIP80-fed cows were pregnant (P = 0.01) than UIP160-fed cows (100, 100, and 91% pregnant for UIP0, UIP80, and UIP160, respectively). Weight loss was greater from start of supplementation to BW nadir in 2004 (P < 0.01; – 12 vs – 49 ± 3 kg for 2003 and 2004, respectively), possibly reflecting previous growing season precipitation differences or diet quality/species composition differences between the years. However, supplement had no effect (P = 0.72) on magnitude of BW nadir (– 28, – 31, and – 32 ± 3 kg for UIP0, UIP80, and UIP160, respectively). Milk production exhibited a quadratic (P < 0.01) response to increasing GP in the supplement with cows fed UIP80 producing the least amount of milk (Table 2). The decrease in milk production when 80 g of propionate salt was added to the supplement suggests that the combination of glucogenic precursors (metabolizable protein from UIP plus propionate salt) shifted nutrient partitioning away from milk production. Similar results were found by Waterman et al. (2002b). Further, the increase in milk production of UIP160 cows compared to UIP80 cows suggests that the additional GP in the UIP160 supplement was used for milk production. Yet these milk production differences did not affect (P = 0.64) calf 205-d weaning weights (241, 238, and 236 ± 4 kg for UIP0, UIP80, and UIP160, respectively).

Supplement did not affect (P ≥ 0.69) tissue sensitivity to insulin, as glucose and insulin AUC and glucose half-lives were similar among supplement groups (Table 3). Glucose half-lives for all cows were similar to those in Waterman et al. (2002a) and these authors determined that cows fed supplements with increased GP in the form of additional metabolizable protein (UIP) and/or propionate salt had shorter glucose half-lives and were more sensitive to insulin than cows fed a traditional cottonseed meal-based supplement with no additional glucogenic precursors (avg 63 vs 100 min, respectively).

All cows in the present study were fed supplements with additional GP from metabolizable protein and/or propionate salt and exhibited similar glucose half-lives to those of the previous study. Cows in both studies were considered insulin-resistant, as glucose half-lives were at least two-fold higher than the normal value of 35 min described by Kaneko (1997).

Feed costs for the supplementation period of this study were $21.09, $30.27, and $39.89/cow for UIP0, UIP80, and UIP160, respectively. To compare benefits of supplementation strategies, results of Waterman et al. (2002b) and the present study were combined (2000, 2001, 2003 and 2004 experiments). The UIP80 treatment group and the group fed supplement containing 100 g propionate salt from Waterman et al. (2002b) were grouped for this comparison and will be referred to as UIP80; the UIP0 supplement was fed in both studies. In all 4 yr, the UIP80-fed cows produced less milk (6615 vs 7386 g/d for UIP80 and UIP0, respectively) and cycled earlier (89 vs 98 d postpartum for UIP80 and UIP0, respectively). Both groups of cows had equivalent calf growth (1.0 kg/d age) and estrous cycle fertility. Pregnancy rates across the 4 yr averaged 91.4% for cows fed UIP0 and 93.1% for cows fed UIP80. An economic comparison (Table 4) was calculated to predict hypothetical results of two 100-cow herds fed either UIP0 or UIP80 for 69 d postpartum (supplementation period feed cost of $21.09 and $30.27, respectively). Additional feed inputs for the year included free-choice mineral ($7.96) and prepartum supplement ($3.36). The UIP0 calves were assumed to be 205 d at weaning; all calves were valued at $2.20/kg at weaning. Even though feed costs for the year were higher for cows in the UIP80 group, their calves had potential to be heavier at weaning because cows fed UIP80 bred back sooner than cows fed UIP0. This resulted in an increase in income of $19.50/cow when UIP80 was compared to UIP0.

Implications

Cows fed the moderate level of glucogenic potential partitioned nutrients away from milk production and towards reproduction. A combination of supplemental glucogenic precursors may be best suited to shift nutrient partitioning in young postpartum range cows grazing dormant forage.

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Table 1. Days to first estrus for 2- and 3-year-old postpartum range cows fed supplements containing increasing amounts of glucogenic potential (0, 80, 160 g/d propionate salt) in 2003 and 2004.

		Year							
		2003				2004			
		Cow Age							
Response	Supplement	2	SE[a]	3	SE	2	SE	3	SE
Days to first estrus	UIP0	56	8	59	5	97	6	72	7
supp × yr × age $P = 0.04$	UIP80	73	8	58	5	66	8	62	7
	UIP160	68	6	53	5	67	8	72	6

[a]Standard error.

Table 2. Milk production and constituents for 2- and 3-year-old postpartum range cows fed supplements containing increasing amounts of glucogenic potential (0, 80, 160 g/d propionate salt) in 2003 and 2004.

	Supplement							Contrast	
Item	UIP0	SE[a]	UIP80	SE	UIP160	SE	OSL[b]	L	Q
24-h milk production, g/d	8278	337	7257	358	8684	341	0.02	0.40	< 0.01
Butterfat, g/d	289	18	271	20	317	18	0.22	0.26	0.19
Protein, g/d	219	10	199	11	236	10	0.06	0.25	0.04
Lactose, g/d	418	18	365	21	433	18	0.05	0.57	0.02
Solids non-fat g/d	712	30	630	34	747	31	0.05	0.42	0.02

[a]Standard error.
[b]Observed significance level.

Table 3. Glucose tolerance test responses of 2- and 3-year-old postpartum range cows fed supplements containing increasing amounts of glucogenic potential (0, 80, 160 g/d propionate salt) in 2003 and 2004.

	Supplement							Contrast	
Item	UIP0	SE[a]	UIP80	SE	UIP160	SE	OSL[b]	L	Q
Glucose area under the curve, units	8786	975	8007	1036	9047	1073	0.76	0.86	0.48
Insulin area under the curve, units	190	19	185	20	209	21	0.69	0.51	0.58
Glucose half-life, min	75	11	66	11	75	12	0.81	0.99	0.53

[a]Standard error.
[b]Observed significance level.

Table 4. Hypothetical economic comparison of two 100-cow herds fed either UIP0 or UIP80 supplements. Results of 4 yr of experiments were combined (current study and Waterman et al., 2002b). Assumptions are defined in text.

Supplement	Pregnancy rate (%)	d to first estrus	Predicted kg calf weaned/cow exposed	Yearly feed cost ($/cow)	Predicted income difference, ($)
UIP0	91.4	98	195	32.41	-----
UIP80	93.1	89	208	41.59	19.50

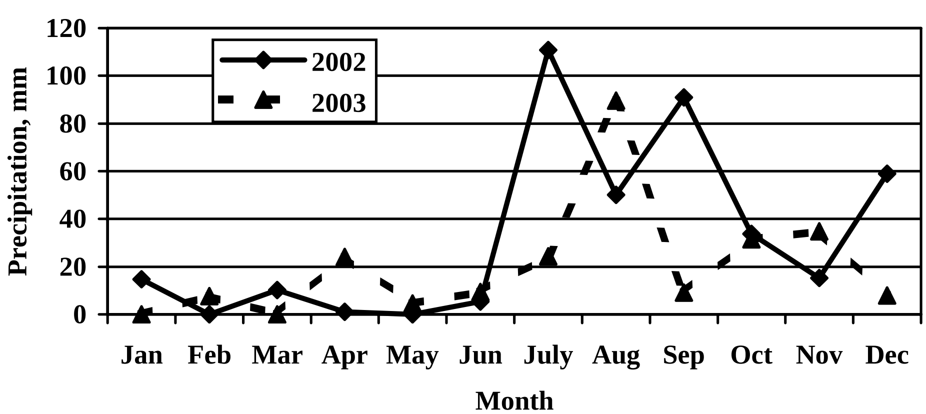

Figure 1. Monthly precipitation of pastures grazed by 2- and 3-yr-old postpartum range cows from February through July for 2002 and 2003. Pastures were grazed in 2003 and 2004 during the present study. Annual precipitation was 391 and 243 mm for 2002 and 2003, respectively.