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GLUCOSE HALF-LIFE DECREASED IN YOUNG POSTPARTUM RANGE COWS FROM SPRING TO SUMMER

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ABSTRACT: Young beef cows experience a negative energy balance after parturition and during lactation when grazing dormant New Mexico range. As a result, sensitivity to insulin may be decreased due to the physiology of lactation and poor forage quality. However, with adequate precipitation during the growing season, forage quality improves, and insulin sensitivity may increase. An experiment was conducted to investigate seasonal changes in nutrient status of young range cows (n = 22) at the New Mexico State University Livestock Research Center and the Corona Range and Livestock Research Center. Two glucose tolerance tests (**GTT**) were conducted, one at 35 d postpartum (winter/spring) and one at 165 d postpartum (summer). At the time of the winter/spring GTT, 2-year-old cows were group fed a mixture of wheat straw and alfalfa hay (7 to 8% CP, OM basis) similar to New Mexico native range in March and April. Cows were grazing New Mexico green forage at the time of the summer GTT. For each GTT, 50% dextrose solution was infused at 0.5 $mL \cdot kg^{-1}$ BW via indwelling jugular catheter and serum was collected at 14 intervals for 180 min beginning 3 min post-infusion. Serum glucose and insulin areas under the curve were calculated using trapezoidal summation. Glucose half-life was estimated by determining the time required for a 50% decrease in peak serum glucose concentration. Glucose area under the curve was smaller ($P < 0.05$) in the summer (9606 ± 573) than in the winter/spring (11337 ± 541). This relationship also existed ($P < 0.01$) for insulin area under the curve (445 ± 25 vs. 302 ± 27 for winter/spring and summer, respectively). Glucose half-life was 50% shorter ($P < 0.01$) in the summer when compared to the winter/spring (87 vs. 45 ± 6 min). Cows grazing green summer forage were more insulin sensitive than cows consuming a poor quality diet. Differences in cow performance between late winter and summer may be due to hormonally regulated differences in energy metabolism.

Key Words: Glucose, Insulin, Season, Beef cattle

Introduction

Beef producers in New Mexico face a unique production setting because calving and breeding in most herds occur while cows are grazing dormant forage. Therefore, young beef cows grazing dormant New Mexico range experience a period of negative energy balance before and after parturition and during lactation (Waterman et al., 2002b). In order to reverse negative energy balance, an adequate supply of glucose must be available and absorbed into tissues to facilitate energy metabolism of acetate and other fatty acids (Weekes, 1991). Ruminants synthesize nearly 100% of their glucose from products of digestion, and the major glucose precursors consist of propionate and amino acids. Ruminal digestion of dormant native range yields small and probably inadequate quantities of these precursors, particularly propionate. Thus, the supply of glucose may be inadequate to support energy metabolism. In addition to the energy balance demand for glucose, the postpartum need for glucose rises dramatically for milk production. As a result of nutrient stress and physiology of lactation, young range cows may be less responsive to the effects of insulin, partitioning glucose toward milk production instead of body weight gain (Weekes, 1991). This insulin resistant state inhibits realimentation and encourages milk production. We hypothesize that as forage quality improves and glucogenic potential of the diet increases, insulin sensitivity increases, leading to more efficient body weight gains and utilization of glucose.

Therefore, the objective of this study was to investigate seasonal changes in glucose partitioning in young postpartum range cows by evaluating insulin sensitivity and glucose clearance when cows were consuming a poor quality diet in the winter/spring and when cows were grazing a higher quality, growing forage during the summer.

Materials and Methods

Two glucose tolerance tests (**GTT**) were conducted to evaluate glucose partitioning in young range cows (n = 22), with suckling calves, at the New Mexico State University Livestock Research Center and the Corona Range and Livestock Research Center. Cows were 2 yr of age and predominantly of Angus breeding with small amounts of Hereford and Simmental influence. Kaneko (1989) recommended the intravenous GTT to evaluate glucose metabolism because the infused glucose level is not so high as to overload the animal or to be lost in the urine, yet high enough to provoke an insulin response, and the infusion can be given easily in a short amount of time. One GTT took place approximately 35 d postpartum (winter/spring, avg cow BW = 344 ± 5 kg) and the other at approximately 165 d postpartum (summer, avg cow BW = 369 ± 5 kg). At the time of the winter/spring GTT, 2-year-old cows were group fed (slick bunk 6 h post-feeding) wheat straw and alfalfa hay mixed to simulate nutrient concentration of New Mexico native range in March and April (6.8 and 8.0 ± 0.9% CP on OM basis, respectively). Diets were balanced based on the average CP content of rumen extrusa samples collected at the Corona Range and Livestock Research Center during March and April from 1997 to 2001 (Appeddu-Richards, 1998; Sawyer, 1999; Waterman, 2000; Waterman et al., 2002b). Ratio of straw to hay was adjusted monthly to reflect forage quality changes of the native range during that time period. Additionally, cows were individually fed one of three 36% CP supplements three times weekly at a rate of 908 g•cow^{-1}•d^{-1}in a companion study (Endecott et al., 2003). Cows were grazing New Mexico green forage at the time of the summer (August) GTT. Rumen extrusa samples from cattle grazing adjacent pastures at the Corona Range and Livestock Research Center during August in 1993, 1996, and 1998-99 averaged 15.8 ± 0.8% CP on an OM basis (Tovar-Luna, 1997; Knox, 1998; Dean, 2001).

For each GTT, 50% dextrose solution was infused at 0.5 mL•kg^{-1} BW via indwelling jugular catheter. Catheters were inserted the morning of each GTT. A 12-gauge hypodermic needle (Jorgensen Laboratories, Loveland, CO or Ideal Instruments, Schiller Park, IL) was used to puncture the jugular vein. One-half of a 2.5-m length of Tygon tubing (0.10 cm i.d., 0.18 cm o.d., Cole-Parmer Instrument Company, Vernon Hills, IL) was threaded through the needle and into the jugular vein. The remaining half of the tubing was taped to the neck and back of the cow. Tubing near the puncture site was glued to the cow's neck in a looped fashion so that it would remain stationary when the cow moved. A blunted 18-gauge needle (Becton-Dickinson, Franklin Lakes, NJ) was inserted in the end of the catheter and a 1-mL syringe (Air-Tite, Virginia Beach, VA) served as the tubing end cap. Serum was collected at –1, 0, 3, 6, 9, 12, 15, 20, 40, 60, 80, 100, 120, 140, 160, and 180 min relative to infusion. Catheters were flushed with 10 mL of 9% saline solution immediately before and after each blood sample was collected and after glucose infusion. The time zero sample was collected immediately after infusion. Blood samples (10 mL) were collected at each sampling time and placed in Corvac serum separator tubes. Samples were centrifuged at 2000 x *g* at 4° C for 25 min for serum collection. Serum was stored in plastic vials at -20° C for later analysis of glucose and insulin. Glucose was analyzed with a commercial kit ([Trinder] method, Sigma Diagnostics, St. Louis, MO). Insulin was analyzed by solid-phase radioimmunoassay (DCP kit, Diagnostic Products Corp., Los Angeles, CA) as validated by Reimers et al. (1982). Serum glucose and insulin areas under the curve were calculated using trapezoidal summation. Glucose half-life was estimated by determining the time required for a 50% decrease in peak serum glucose concentration.

Data were analyzed as a completely randomized design by analyses of variance using the GLM procedure of SAS (SAS Inst., Inc., Cary, NC) with cow as the experimental unit. Variables were analyzed as a 2 x 3 factorial arrangement using the main effects of season, supplement and their interaction in the model.

Results and Discussion

Neither the interaction of supplement and season nor the main effect of supplement was significant ($P > 0.05$); therefore, only seasonal effects are presented. Glucose area under the curve was smaller ($P < 0.05$) in the summer (9606 ± 573) than in the winter/spring (11337 ± 541). This relationship also existed ($P < 0.01$) for insulin area under the curve (302 ± 27 vs. 445 ± 25 for summer and winter/spring, respectively). A smaller glucose area under the curve coupled with a smaller insulin area under the curve in the summer indicates that cows were more sensitive to the effects of insulin; infused glucose was absorbed by the tissues more quickly than in the winter/spring and less insulin was needed. Waterman et al. (2002a) conducted a GTT at 65 d postpartum on 2-year-old cows grazing dormant New Mexico range fed protein supplement and found an average insulin area under the curve of 300 ± 51 and an average glucose area under the curve of 14620 ± 1004 over three different supplement groups. This supports the idea that cows grazing dormant forage have an inflated glucose area under the curve and are less responsive to insulin. Glucose half-life was 50% shorter ($P < 0.01$) in the summer when compared to the winter/spring (87 vs. 45 ± 6 min). Even in the summer when cows were grazing high-quality forage, glucose half-life was elevated over the normal glucose half-life of 35 min described by Kaneko (1989). Waterman et al. (2002a) found an average glucose half-life of 75 ± 15 min for grazing 2-year-old cows from three supplement groups at 65 d postpartum.

In both GTT in this study, cows were infused with the same amount of glucose per kg of body weight. However, in the summer, cows cleared the same amount of glucose with less insulin than in the winter/spring and did so in half the amount of time it took in the winter/spring. Therefore the cows were more insulin sensitive at the time of the summer GTT than they were at the time of the winter/spring GTT. One possible explanation for this phenomenon could be due to physiological changes that occur as lactation progresses (Bines and Hart, 1982). Cows become more sensitive to insulin as lactation progresses (Weekes, 1991). It is also possible that diet quality, as influenced by vegetation maturity, may influence glucose homeostasis. Tovar-Luna et al. (1995) reported twice-normal glucose half-lives after GTT (66 ± 5 min) for non-pregnant, non-lactating yearling heifers (269 ± 21 kg) fed a low quality buffalo grass straw diet (6% CP, OM basis) and protein supplement. This provides evidence that diet influences insulin sensitivity, as glucose half-lives were longer than normal for non-lactating animals. This suggests that seasonal differences in glucose metabolism and insulin sensitivity are at least partially due to seasonal changes in diet quality and intake, not totally due to stage of lactation. We interpret our results to imply that differences in body weight change occurring in winter/spring and summer are not only due to differences in physiological state or nutrient quality of the diet, but also due to the direction of glucose partitioning.

Implications

Lactating cows grazing green summer forage were more insulin sensitive than lactating cows consuming a protein-supplemented wheat straw and alfalfa diet. Supplementation of range cows after calving when they are grazing dormant forage is a common practice, with the goal of improving energy balance. Results from this study suggest that even though a supplement is fed after calving, the nutrients that it supplies may not enter the tissues efficiently. Supplements may provide an increased supply of glucose precursors, but if cows are insensitive to insulin at the time of supplementation, then less efficient utilization of nutrients will occur for realimentation. Differences in cow performance between winter and summer may be due to differences in glucose partitioning.

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