Supplementation of DDGS to beef cows during late gestation: Impacts on maternal weight, voluntary feed intake and nutrient flux to the calf

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The objective of this study was to investigate the effects of corn dried distillers grains plus solubles (DDGS) supplementation to beef cows during late gestation on maintenance of body condition and weight, voluntary feed intake behavior, and factors affecting milk and milk nutrients for the calf. Results indicate supplementation offers advantages to the cow and calf, which in turn offers potential economic advantages to the cow-calf producer.

Summary

On day 201 of pregnancy, 27 aged cows were divided randomly into a control group (CON; n = 15) or a supplemented group (SUP; n = 12) and provided the same basal diet of corn stover and silage for ad libitum intake. Supplemented cows were fed DDGS at 0.3 percent of body weight. On day 270 of pregnancy, all cows were placed on the same diet, which was fed through the first 56 days of lactation. To investigate the effects of DDGS supplementation, cows were weighed every two weeks, color Doppler ultrasound assessments of uterine and mammary arterial blood flow were performed during pregnancy and lactation, calf birth weights and placenta weights were collected, and cows and calves were weighed again every two weeks until day 56 of lactation. Colostrum and milk samples also were collected to assess nutrient delivery to the calf after birth. Throughout the study, individual intake behavior was monitored using Insentec feeders. Finally, the weaning weight of calves was obtained in the subsequent autumn.

Treatment differences were observed for voluntary intake behavior during late gestation, maternal body condition and weight, uterine blood flow, calf birth and weaning weights, and milk production measures. Our study found numerous advantages to supplementing DDGS to gestating beef cows during late pregnancy, further highlighting the importance of high-quality nutrition during pregnancy, specifically in regard to protein availability in the diet. Advantages in calf weights, as well as enhanced milk production in their dams, can be of great economic value to the cow-calf producer. The present study suggests these benefits could be a result of altered uterine blood flow or mammary gland function.

Introduction

Dramatic increases in corn production in North Dakota have resulted in more corn production byproducts, such as corn stover, being available to producers to use for winter feed (Winterholler, 2012). The byproducts of corn-based ethanol production, particularly dried distillers grains plus solubles (DDGS), can provide an important supplemental energy and protein source for livestock (Klopfenstein et al, 2008).

Making use of these byproducts for pregnant beef cows during the winter offers economic benefits to cow-calf operations (Kim et al., 2008). Many previous studies have demonstrated the benefits of supplementing dams fed low-quality forage with DDGS, such as increased weaning weights and ADG (Stalker et al., 2006) spring-calving cows (yr 1, n = 136; yr 2, n = 113; yr 3, n = 113, increased growth and reproductive success of heifer calves (Martin et al., 2007) cows received 0.45 kg/d of a 42% CP supplement (PS, and improved quality grade of steer calves (Larson et al., 2009).

Research in the area of developmental programing across species has demonstrated the significant influence of the maternal system on fetal development and offspring potential, as well as growth trajectories and even development of disease in adult life (Barker, 2004). In cattle, maternal nutrition is essential to fetal and placental development, which can influence the lifetime performance of the calf (Funston et al., 2010) considerable effort has been made to understand how nutrition influences health and productivity during the postnatal period. Whereas maternal nutrition during pregnancy plays an essential role in proper fetal and placental development, less is known about how maternal nutrition affects the health and productivity of the off-

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spring. Conceptus growth is sensitive to direct and indirect effects of maternal dietary intake. Even from the earliest stages of embryonic life, when nutrient requirements for conceptus growth are negligible, alterations in tissue composition can occur, influencing future growth of the compromised organ system. Not only is neonatal health compromised, but subsequent health may also be programmed because offspring from undernourished dams have exhibited poor growth and productivity and have developed significant diseases later in life. Although the literature is now evolving, with increasing evidence of how maternal nutrient restriction impairs several prenatal physiological variables, few studies have evaluated postnatal growth and development in livestock species, and fewer have evaluated it in beef cattle. In addition, very few studies have evaluated restriction of specific components of the diet during pregnancy (such as protein).

One way to quantify nutrient delivery to the fetus is to measure uterine arterial blood flow (Ferrell, 1991). Modification of uterine blood flow and nutrient transfer capacity enables increased oxygen and nutrient delivery to the growing fetus (Vonnahme and Lemley, 2011).

In addition to uterine blood flow, mammary gland blood flow is a vital component for milk synthesis and, therefore, nutrient delivery to the calf after birth. Mammary blood flow has a strong positive correlation with milk yield (Götze et al., 2010). Maternal nutrient intake during gestation can alter growth factors during pregnancy that facilitate nutrient delivery to the still-developing mammary gland in anticipation of colostrum and milk production after birth (Svennersten-Sjaunja and Olsson, 2005). Additionally, differing planes of protein and energy nutrition can influence milk production to varying degrees, depending on the timing of differences in gestational diet (McSweeney et al., 1993, Sullivan et al., 2009).

We designed our experiment with these concepts in mind as well as an interest in using corn by products. We hypothesized that DDGS supplementation would benefit maintenance of cow body condition and weight via altered intake patterns, and influence nutrient delivery to the calf in (uterine blood flow) and out (colostrum and milk production) of the womb, as well as affect calf weights at birth, during early growth and at weaning. Therefore, our objectives were to determine the effects of DDGS supplementation on late gestational beef cows' performance, as well as offspring growth trajectories.

Experimental Procedures

All procedures involving animals were approved by the NDSU Animal Care and Use Committee. Twenty-seven beef cows (Angus or Angus x Simmental; 1,486 pounds of body weight [BW]; 6 years of age) were divided randomly into a control group (CON; n = 15) and a treatment group (SUP; n = 12). Cows were housed at the Beef Cattle Research Complex in two adjacent pens, one for each treatment group.

A basal diet of 90 percent corn stover and 10 percent corn silage (dry basis, 5 percent crude protein, marginally energy deficient, rumen-degradable protein deficient) was fed for ad libitum intake to both groups, with the SUP group was supplied DDGS at 0.3 percent of BW (dry basis) in separate feeders.

Corn silage inclusion was increased to 20 percent on day 245 of gestation and to 30 percent on day 260 to meet increased nutritional demands during pregnancy, while DDGS supplementation remained the same. On day 270 of gestation, close to expected parturition, all cows were fed the same diet (48 percent corn stover, 30 percent corn silage, 22 percent DDGS; dry basis; 10.8 percent crude protein) for ad libitum intake for 10 weeks; DDGS supplementation ceased and was incorporated into diets.

All cows were fitted with radio-frequency identification tags to facilitate monitoring of individual intake and feeding behavior during the experiment. Feeding behavior measurements (number of meals, size of meals, time eating meals) were characterized. Feeding behavior reflects forage intake (not including the supplement) during gestation and total diet consumption during lactation.

During pregnancy, cows were weighed approximately every two weeks until day 242 of gestation. Arterial blood flow to the uterus was assessed using color Doppler ultrasonography on days 180, 216 and 246. On the last ultrasound day, arterial blood flow to the mammary gland also was measured. Cows and calves were weighed at birth and every two weeks from their calving date until day 56 of lactation. At calving, calf and placental measures were recorded, and colostrum samples were collected from the rear right quarter.

On day 44 of lactation, cows were milked using an automatic milking machine to determine milk production. After milking, blood flow to the mammary gland was measured. Dairy Herd Improvement Association (DHIA) analysis of milk components also was performed. Calf weaning weight was recorded and adjusted to day 205 of age.

Results and Discussion

Gestation

Cows began the experiment with an average body condition score of 5.9, but by calving, CON cows decreased body condition to an average score of 4.9 ($P < 0.01$) while SUP cows' body condition did not change, averaging 5.7 ($P = 0.79$; Fig. 1A). Supplemented cows gained weight ($P < 0.01$) at an average rate of 2.80 pounds daily, and CON cows had a tendency to lose weight ($P = 0.06$) at an average rate of 0.51 pound daily (Figure 1B). During the late pregnancy period, SUP cows had greater total uterine blood flow than CON cows ($P < 0.01$), while blood flow increased in both groups as pregnancy advanced ($P = 0.02$; Figure 2). The heart rate of SUP cows also was greater by the last ultrasound day ($P < 0.01$), certainly contributing to the difference in blood flow.

Intake and intake behavior during pregnancy differed between treatment groups as well. SUP cows consumed more ($P = 0.01$) forage than CON cows. SUP cows also consumed more meals ($P = 0.03$) and ate faster ($P < 0.01$).

Calving and Lactation

Calves born to SUP cows tended to be heavier than those from CON cows (95.5 vs. 89.3 pounds; $P = 0.06$). However, we found no other impacts of maternal diet on any other birth (gestation length, time for calf to stand, crown rump length, heart girth circumference or calf weight at 24 hours) or placental (total weight, cotyledon weights, size or number of cotyledons) measures. Despite no differences between treatment groups for calf weight gain during early lactation ($P = 0.68$), we observed a difference at weaning, with SUP cows' calves being heavier than the CON cows' calves ($P = 0.05$; 683 vs. 644 pounds).

Treatment did not affect colostrum production ($P = 0.15$). By day 44 of lactation, SUP cows tended to produce more milk than CON cows (29.8 vs. 22.5 pounds/day; $P = 0.07$). We found no differences between treatments for milk components.

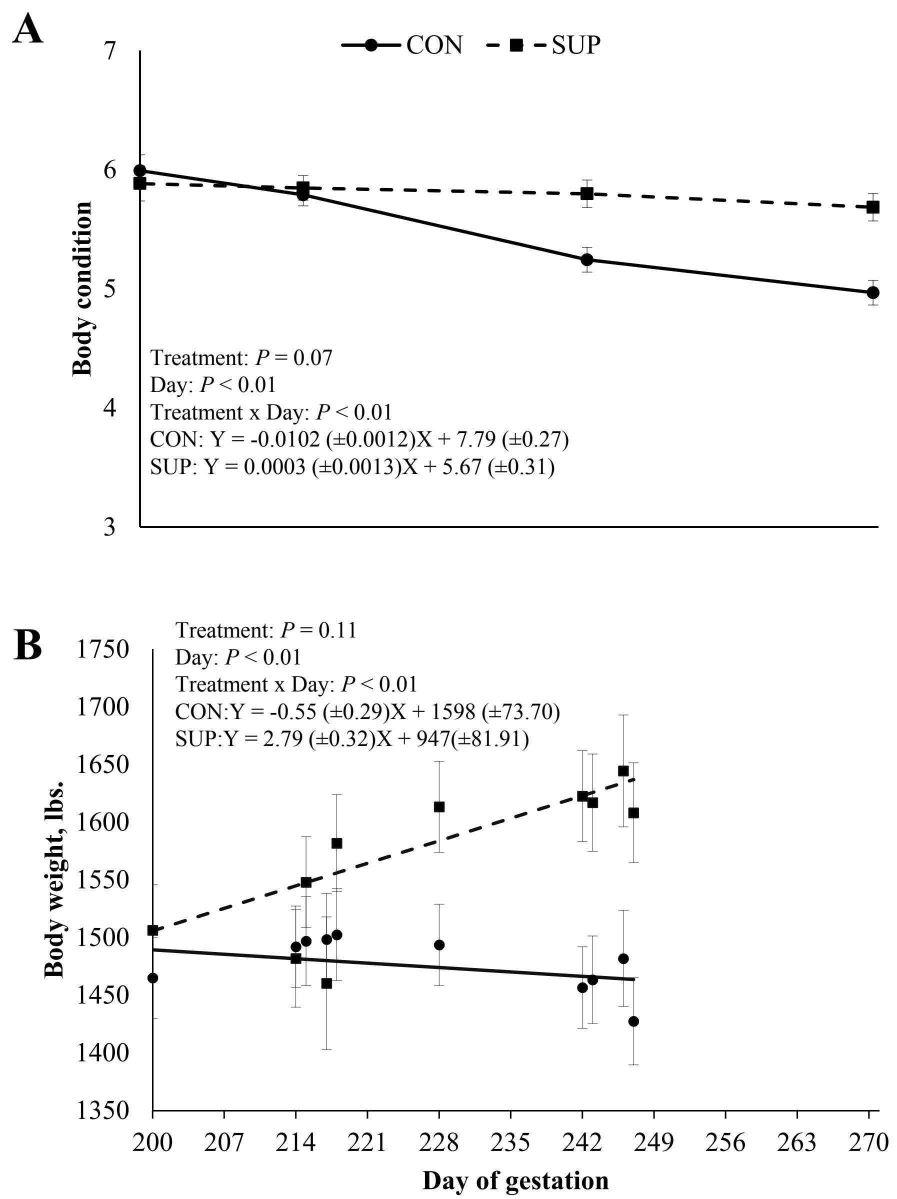

Figure 1. A) BCS and B) body weight of cows during late gestation.

Mammary gland blood flow differed by treatment during late gestation, when cow heart rate and blood flow to the mammary gland on the same side as the pregnant uterine horn were greater ($P \leq 0.03$) in SUP cows, but the total blood flow was not different ($P = 0.12$). The differences observed during gestation did not carry over to ultrasound observations during early lactation.

Dissimilarities observed in intake behavior during late gestation also did not carry over as much into early lactation, when only differences in time spent eating and meal size were observed. However, neither of these measures impacted total intake ($P = 0.08$).

Finally, the differences between the treatment groups for maternal body condition and weight maintenance waned during early lactation. Body condition ($P = 0.14$) and weights ($P = 0.23$) were similar dur-

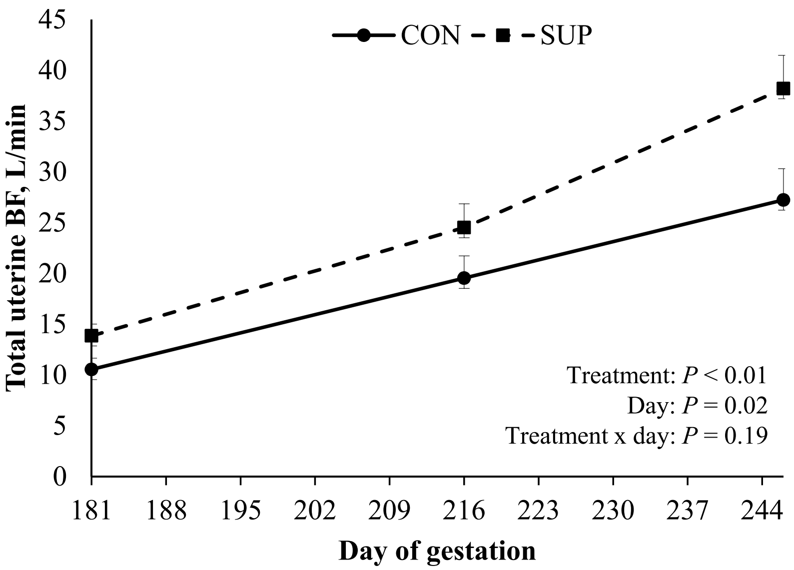

Figure 2. Total uterine blood flow (BF) of beef cows fed control or control plus supplement from days 201 to 270 of gestation.

ing lactation; CON cows consumed the same, higher-quality lactation diet as the SUP cows (Figure 3).

Discussion

In our study, supplementation of DDGS to cows fed a low-quality forage diet altered intake behavior during late gestation, which in turn impacted maintenance of maternal body weight and condition, likely as a function of increased consumption of rumen-degradable protein, total metabolizable protein and net energy. By consuming more of the basal diet in addition to DDGS, the fact that cows from the supplemented group were heavier and had better body condition leading up to calving than control cows was not surprising.

We also observed a tendency for increased calf birth weights, a difference which also was present at weaning. The weight advantage of supplemented cows' calves could be a result of enhanced uterine blood flow because this directly contributes to nutrient delivery to the developing calf.

Increased uterine blood flow in SUP cows also could explain the increase in blood flow to the mammary gland on the same side as the pregnant horn, potentially aiding in preparation for lactation and even greater daily milk production as measured on day 44 of lactation. Perhaps the tendency for greater daily milk production in supplemented cows also aided in calf growth and, thus, the difference in weaning weights.

In conclusion, we feel that this research can contribute to new approaches for optimizing fetal calf development and subsequent beef cattle productivity with the use of corn byproducts (corn stover and DDGS). In particular, this work will further acquaint producers with the value of supplementing cows during late pregnancy, notably via the use of DDGS as a beneficial energy and protein source that subsequently could aid in maintenance of healthier cows and production of more successful calves.

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Literature Cited

Barker, D.J.P. 2004. The developmental origins of well-being. Philos. Trans. R. Soc. Lond. 359:1359–66.

Ferrell, C. 1991. Maternal and fetal influences on uterine and conceptus development in the cow: II . Blood flow and nutrient flux . J. Anim. Sci.:1954–1965.

Funston, R.N., D.M. Larson and K.A. Vonnahme. 2010. Effects of maternal nutrition on conceptus growth and offspring performance: Implications for beef cattle production. J. Anim. Sci. 88:E205–E215.

Forbes, J.M. 1995. Voluntary food intake and diet selection in farm animals. CAB International. Wallingford, UK.

Kim, Y., N.S. Mosier, R. Hendrickson, T. Ezeji, H. Blaschek, B. Dien, M. Cotta, B. Dale and M.R. Ladisch. 2008. Composition of corn dry-grind ethanol by-products: DDGS, wet cake, and thin stillage. Bioresource Technol. 99:5165–5176.

Klopfenstein, T.J., G.E. Erickson and V.R. Bremer. 2008. Board-invited review: Use of distillers by-products in the beef cattle feeding industry. J. Anim. Sci. 86(5): 1223-31.

Larson, D.M., J.L. Martin, D.C. Adams and R.N. Funston. 2009. Winter grazing system and supplementation during late gestation influence performance of beef cows and steer progeny. J. Anim. Sci. 87:1147–1155.

Martin, J.L., K.A. Vonnahme, D.C. Adams, G.P. Lardy and R.N. Funston. 2007. Effects of dam nutrition on growth and reproductive performance of heifer calves. J. Anim. Sci. 85:841–847.

McSweeney, C.S., L.A. Fitzpatrick, M.J. D'Occhio, D. Reid and K.W. Entwistle. 1993. Reducing post-partum anoestrous interval in first-calf *Bos indicus* crossbred beef heifers. 1. Effects of pre- and post-partum supplementation strategies. Aust. J. Agric. Res. 44:1063–1077.

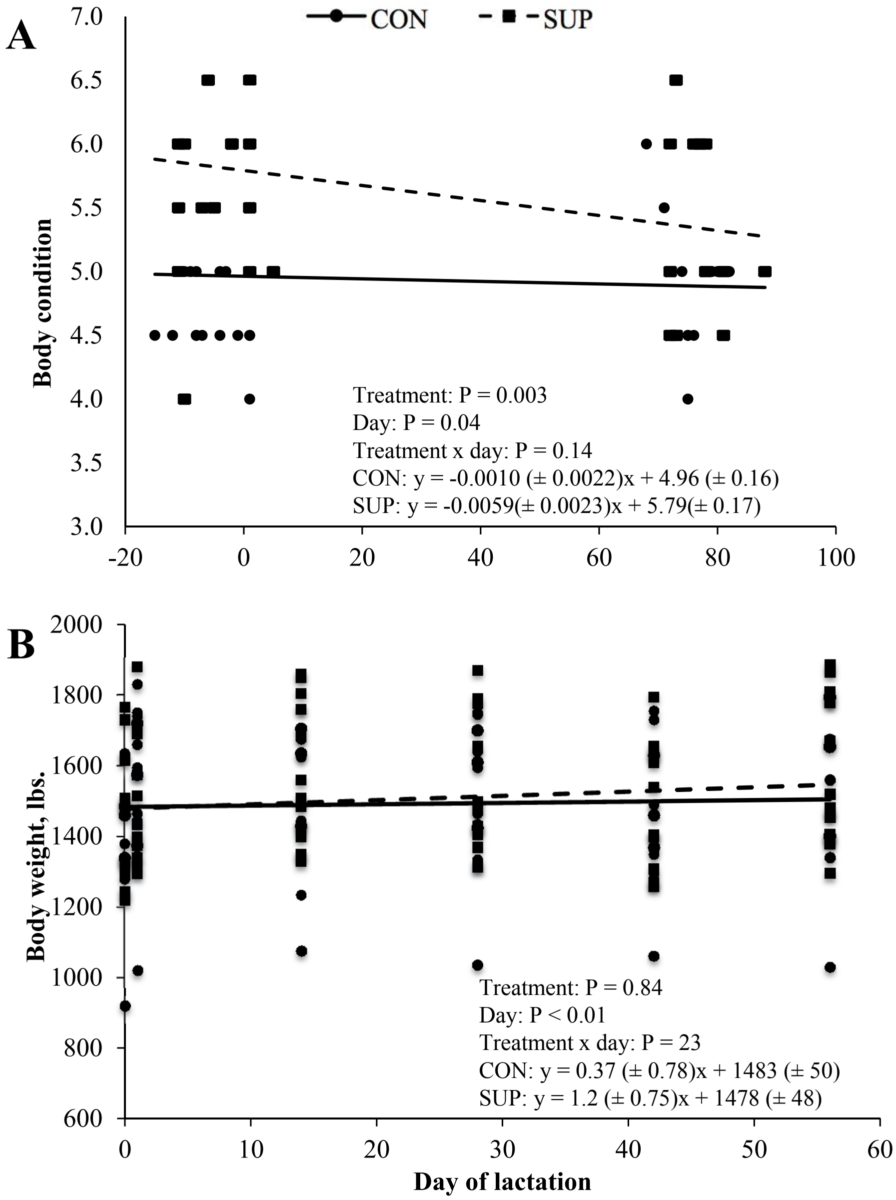

Figure 3. A) Body condition and B) body weights of cows during early lactation.

NRC. 2000. Nutritional requirements of beef cattle. 7th rev. ed. Natl. Acad. Press, Washington, DC.

Stalker, L., D.C. Adams, T.J. Klopfenstein, D.M. Feuz and R.N. Funston. 2006. Effects of pre- and postpartum nutrition on reproduction in spring calving cows and calf feedlot performance. J. Anim. Sci. 84:2582–9.

Sullivan, T.M., G.C. Micke and V.E.A. Perry. 2009. Influences of diet during gestation on potential postpartum reprductive performance and milk production in beef heifers. Theriogenology. 72:1202-1214.

Svennersten-Sjaunja, K., and K. Olsson. 2005. Endocrinology of milk production. Dom. Anim. Endocrin. 29:241-258.

Vonnahme, K.A., and C.O. Lemley. 2011. Programming the offspring through altered uteroplacental hemodynamics: How maternal environment impacts uterine and umbilical blood flow in cattle, sheep and pigs. Reprod. Fertil. Dev. 24:97–104.

Winterholler, S.J., C.P. McMurphy, G.L. Mourer, C.R. Krehbiel, G.W. Horn and D.L. Lalman. 2012. Supplementation of dried distillers grains with solubles to beef cows consuming low-quality forage during late gestation and early lactation. J. Anim. Sci. 90:2014–2025.