

REPRODUCTIVE PERFORMANCE OF BEEF HEIFERS SUPPLEMENTED WITH CORN GLUTEN FEED AND RUMEN-PROTECTED FAT BEFORE BREEDING

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ABSTRACT

A rumen-protected fat (Megalac®) and corn gluten feed supplement (RPCG) was fed to heifers to determine reproductive effects. Angus (n=24) and Polled Hereford (n=17) heifers (initial BW 376.9 ± 29.9 kg; average age 14 mo) were randomly assigned to treatments 60-d before breeding began, which were Control (n=20; no supplementation), or RPCG supplement (n=21; 8% Megalac®, 92% corn gluten feed; fed 5 d/wk at 3.45 kg/heifer daily). Breeding began April 14, using AI (d 1 to 44), and bulls (d 45 to 71). Heifer BW (kg), and ultrasound subcutaneous fat (cm), for Control and RPCG, respectively, were: February 11 = 376 and 373, 2.23 and 2.15, SE 6.4 and 0.11; April 11 = 431 and 434, 2.20 and 2.36, SE 6.4 and 0.11; June 18 = 444 and 446, 2.09 and 2.22, SE 3.1 and 0.11; Control vs. RPCG, $P > 0.10$ for BW and ultrasound subcutaneous fat. Serum cholesterol (CHO; mg/dl), high-density lipoprotein (HDL; mg/dl), leptin (ng/ml), on d 60 respectively, for Control were: 139.6, 100.9, and 8.38; and RPCG were: 162.9, 122.2, and 10.70; (Control vs. RPCG, for CHO and HDL; $P < 0.01$; and leptin; $P < 0.05$). Interactions of treatment x sampling date for CHO and HDL ($P < 0.01$) and for leptin ($P < 0.05$) showed each lipid increasing with time on RPCG compared with Control. Feeding RPCG to heifers before breeding increased serum lipids by d 60, resulting in a trend for increased pregnancy rates in these heifers (RPCG vs. Control, 79.2 vs. 56.2%; $P > 0.10$).

INTRODUCTION

Recent research has been focused on management practices that may influence and improve reproductive efficiency in yearling heifers. Genetics and nutrition have the greatest effects on age at puberty in beef heifers (Wiltbank et al., 1966), and a high level of nutrition decreased the age at onset of puberty. Gasser et al., (2006) reported that increasing dietary energy intake in early-weaned heifers through feeding a high-concentrate diet decreased age at puberty regardless of the diet fed. Conception occurring earlier during the first breeding season for a heifer results in positive effects on reproductive performance of that cow for the rest of her lifetime (Lesmeister et al., 1973).

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Many beef heifers in the Southeastern United States are bred between February and June corresponding to increasing availability of high quality, winter and early spring production of summer perennial grasses that can meet nutrient requirements for growth and breeding. Poore et al. (2002) reviewed research that demonstrated the effectiveness of corn gluten feed as a protein and energy supplement for growing cattle and beef cows, with greater utilization on low- protein diets. The belief that fat supplementation of heifers grazing winter annuals could negatively impact digestion of structural carbohydrates (Jenkins, 1993), resulted in few research reports using fat as the energy source for grazing heifers. Rumen-protected fat has been utilized to meet or exceed energy needs of cattle, while minimizing DMI reductions and decreased OM digestion associated with fat supplementation (Spicer et al., 1993; Filley et al., 2000). Our objectives were to determine effects of feeding a corn gluten feed supplement containing rumen-protected fat on serum lipids and reproductive performance of yearling heifers grazing winter annual pastures.

MATERIALS AND METHODS

Animals and Experimental Procedures. Angus heifers (n=24; initial BW 386.4 ± 29.2 kg) and Polled Hereford (PH) heifers (n=17; initial BW 363.2 ± 25.6 kg); were used in an experiment to determine reproductive performance of heifers on two dietary treatments. Heifers (average age 14 mo) were ranked on February 11 by BW, breed, and sire, and then randomly assigned to either a control (C) or to a rumen-protected fat and corn gluten feed (CGF) supplemented treatment (RPCG). The rumen-protected fat was provided in a commercial product (Megalac®, Church and Dwight, Inc., Princeton, NJ) that contained calcium salts of fatty acids. The C heifers (n=20; initial BW 379.0 ± 32.0 kg) grazed pastures with no supplemental feeding. The RPCG heifers (n=21; initial BW 374.6 ± 28.1 kg); grazed pastures and were fed the RPCG supplement (mixture of 8% Megalac, 92% corn gluten feed fed 5 d/wk at 3.45 kg/d) during the 60-d prebreeding period. Heifers grazed dormant 'Coastal' bermudagrass (*Cynodon dactylon*) pastures that had been sod-seeded the previous November with 'Passerell' annual ryegrass (*Lolium multiflorum* Lam.; 26.73 kg/ha; Pennington Seed Co., Madison, GA) during the prebreeding and breeding intervals. Heifers assigned to the two treatments were rotated on the two pastures twice during the prebreeding supplemental period to allow each treatment similar forage over the course of the prebreeding interval. Heifers on RPCG were fed as a group in respective pastures. Bermudagrass hay was provided free-choice in hay feeders to each group of heifers. Heifer BW on d 1 and d 60 were averages of two consecutive daily unshrunk BW. All heifers and bulls were managed under procedures approved by the University of Georgia Animal Care and Use Committee Guidelines.

On d 1 (February 11), heifers were weighed, subcutaneous ultrasound fat (USF) depth was measured at the 12th rib, and heifers received visual BCS (1 = emaciated, 9 = obese). A blood sample was taken by tail veinipuncture. On d 28 (March 11) midway through the supplementation period, the heifers were weighed, condition scored, and blood samples were taken via tail veinipuncture. On d 60 (April 11) and d 128 (June 16) heifers were weighed, BCS and USF were recorded, and final blood samples were collected on d 60. Heifer BW were recorded on d 133 (June 23), which was the last day

of the breeding interval, and at 28-d intervals from d 128 (June 16) to d 218 (September 19).

On April 14, the C and RPCG heifers were combined into one herd for the breeding season which consisted of a 44-d AI interval followed by a 27-d natural service clean-up interval. Heifers were monitored for estrus activity by visual observation twice daily for 30 min at 0700 and 1900. In addition to visual observation, a Heatwatch System (DDX Inc., Denver, CO) was used to monitor estrus mounting activity. Heifers were bred 12 h after the onset of estrus based on the Heatwatch System data. The onset of estrus was defined as the first of two mounts in a 4 h period. If no Heatwatch system data was available, the heifer was bred 12 h after the observed standing heat. At the end of the AI breeding interval heifers were regrouped by breed and put into two adjoining pastures with a bull of the opposite breed. These bulls passed a breeding soundness examination 1 wk before the start of the breeding season. On September 17 pregnancy examinations via rectal palpation were completed for each heifer, if pregnant fetal age was estimated.

Chemical Analyses of Diets and Blood Components. Heifer diets were sampled and chemically analyzed for DM and CP using AOAC (1990) procedures, and ADF and NDF were determined using the methods outlined by Van Soest et al. (1991). The TDN and NEm were determined using equations in NRC (1996). Round bales of hay were sampled in three different locations of each bale using a core sampling tube and then composited by bale. Each composite was ground through a 1-mm screen. Hay composites were analyzed in duplicate, and averaged (Table 1). The CGF was sampled from several sites in the batch of the byproduct used in the experiment, then composited before being analyzed for nutrient content. Ryegrass forage was sampled on d 18 and d 48 of the supplementation period. Pastures were sampled at three different locations within each pasture using a 0.093 meter square, and forage was cut at ground-level, using electric shears. The samples were dried in a forced-air oven at 60°C for 48 h, ground through a 1-mm screen, composited by pasture, and analyzed for nutrient concentrations.

blood samples were refrigerated immediately after collection, and cooled overnight at 4°C before being centrifuged ($2860 \times g$ for 20 min at 4°C) to separate serum. Serum was collected, frozen, and stored for later analysis. A Boehringer Mannheim/Hitachi 912 analyzer was used to analyze serum for blood urea nitrogen (**BUN** / Direct analysis), cholesterol (Cholesterol / HP; Roche Diagnostics, Inc., Indianapolis, IN), high-density lipoprotein (**HDL**; HDL- C plus 2nd generation; Roche Diagnostics), and triglycerides (Triglycerides/ GB; Roche Diagnostics). The low-density lipoprotein (**LDL**) was calculated using the formula: Total Cholesterol - (HDL [triglycerides/5]). Circulating levels of leptin were determined by RIA (Delavaud et al., 2000).

Statistical Analyses. The statistical design was a 2×2 factorial with breed and treatment (T) as main effects, and heifers as individual experimental units as the source of error (Ciccioli et al., 2003; Lents et al., 2005). The heifer performance data (BW, BCS, and USF) and reproductive data were analyzed using Proc MIXED (SAS, 2002). The BW and reproductive data were in one analysis, with the initial BW (February 11) used as a

covariate for all subsequent weight measurements. Additional analyses were conducted for the serum components as a $2 \times 2 \times 3$ factorial (breed, treatment, and date as factors) using Proc MIXED (SAS, 2002). Heifer was included as a random effect in the previous model. The program Proc CORR was used to determine correlations between USF at d 60, the last day of the prebreeding treatment period and pregnancy rate. For blood components measured on the three dates during the prebreeding interval (d1, d 28, and d 60 prebreeding), only triglycerides and leptin showed correlations between the three sampling dates of measurement, while cholesterol, HDL, and LDL showed correlations only for d 28 and d 60.

RESULTS AND DISCUSSION

Nutrient Intake Effects. The effects of feeding the MCG supplement during the prebreeding interval on heifer BW, USF, and BCS are shown in Table 2. Initial BW was used as a covariate with all BW data after the first measurement, and this covariate removed effects of breed differences in BW. On day 28 (March 11), approximately half way through the prebreeding period, both BW and BCS were each greater ($P < 0.05$) for MCG heifers, and BCS were greater ($P < 0.05$) for PH heifers than Angus heifers. On d 60 (April 11) the date corresponding to the end of the prebreeding period, BW, BCS, and USF were similar ($P > 0.10$) for treatments and breeds. Pasture nutrient composition (Table 1) reflected high quality sod-seeded ryegrass that was available for grazing throughout the prebreeding interval. Hay was provided in each pasture as an alternative roughage source (Table 1), and hay disappearance was low, but similar for the treatments during the 60-d prebreeding interval (C=1.65 kg DM/d; MCG=1.60 kg DM/d). Means of BW, BCS, and USF were not different ($P > 0.10$) on subsequent data collection dates, but breed tended ($P < 0.18$) to affect BW. Likewise, BW, BCS, and USF were unaffected by treatment on later dates when measurements were recorded.

Pastures used in this experiment were of high nutritive quality, as indicated by forage analyses (Table 1), providing forage CP that exceeded NRC (1996) requirements for beef heifers for maintenance, and which allowed heifers on both treatments to continue to grow and while increasing BW (Table 2). Elevated CP in February pasture samples (Table 1) reflected N fertilizer applications to pastures that occurred soon before the samples were obtained for analyses. Feeding the MCG supplement added more CP to total dietary CP provided by the sod-seeded ryegrass pastures being grazed by heifers. In most situations CGF is fed to growing beef cattle primarily as a CP supplement, secondarily as an energy source (Poore et al., 2002). In our study, CGF was chosen as a carrier for rumen-protected fat (Megalac®), a product which has a distinctively strong detergent odor, and may not be readily consumed by grazing cattle, or in drylot feeding situations. As indicated in Table 2, heifer BW at d 60 was unaffected by RPCG supplementation. The extra CP in CGF contained in the RPCG diet was apparently substituted for forage CP and other nutrients, because BUN values for both treatments were elevated (Table 3), reflecting increased forage CP concentrations shown in Table 1. The BUN was similar for heifers on the two treatments on d 1 (Table 3), BUN increased ($P < 0.01$) for C, but not RPCG on d 28, resulting in a treatment x sampling date interaction ($P < 0.01$), and heifer breed did not affect ($P > 0.10$) BUN concentrations.

Elizalde et al. (1998) fed corn gluten feed or corn to growing steers grazing high quality tall fescue (17 to 24 % CP) in spring at 3.18 kg/d, resulting in increased ADG and a 21% reduction in forage intake for steers fed corn gluten feed compared with corn. Forage intake was not measured in our study, but the RPCG heifers were fed similar amounts of the supplement composed primarily of CGF as were grazing steers in the study of Elizalde et al. (1998), which is additional evidence that heifers fed RPCG were apparently substituting the supplement for pasture forage.

Feeding rumen-protected fat with CGF during the prebreeding interval had minimal effects on BW or BCS of heifers, except for a difference observed at d 28 for both measurements (Table 2). Pastures grazed by the heifers were similar in nutrient content, with similar TDN and NEm values for pastures (Table 1), and any pasture nutritional differences were minimized by using pasture rotation to allow heifers on each treatment access to each pasture. Heifer breed affected heifer BW throughout the prebreeding, breeding, and post-breeding intervals (Table 2), even when initial BW was used as a covariate. Likewise, heifer breed affected BW at the start of the study, relative to the USF data, since PH heifers had greater USF values than A heifers. However, on subsequent dates there were no USF differences associated with breed or treatment.

Treatment Effects on Blood Components and Heifer Pregnancy. Blood serum samples from C and RPCG heifers on d 1, d 28 and d 60 of the prebreeding interval were analyzed for concentrations of serum components (Tables 3). The BUN, cholesterol, triglycerides, HDL, LDL, and leptin were affected by treatment \times sampling date interactions (Table 3). Cholesterol and HDL were affected by treatment \times breed interactions, however, none of the serum components were affected by treatment \times breed \times sampling date interactions ($P > 0.10$). Serum BUN from C and RPCG heifers was reported for d 1 and d 28 (Table 3), but insufficient serum volume remained on many d 60 samples after other analyses were conducted to complete BUN analyses for this sampling date. Serum BUN was similar for C and RPCG heifers on d 1, BUN increased ($P < 0.01$) for C heifers between d1 and d 28, and BUN was greater ($P < 0.01$) for C than RPCG on d 28. In addition to the treatment \times sampling date interaction ($P < 0.01$) for BUN, heifer breed affected BUN resulting in greater concentrations for PH heifers (Angus vs. PH, 21.7 vs. 25.2 mg/dl; $P < 0.01$).

A recurring pattern was observed for all serum lipid components in C heifers, in which concentrations of each component in C and RPCG heifers were similar on d 1. Lipid components in heifers on RPCG had variable LDL concentrations over sampling dates. Serum cholesterol in C and RPCG heifers was affected by treatment \times date (Table 3; $P < 0.01$) and treatment \times breed (Table 4; $P < 0.05$) interactions. Cholesterol in C heifers declined ($P < 0.05$) from d 1 to d 28, but increased ($P < 0.01$) to a greater value on d 60 than on d 1 (Table 3). Cholesterol in RPCG heifers increased from d 1 to d 28 ($P < 0.01$), and d 28 to d 60 ($P < 0.05$), and cholesterol was greater ($P < 0.01$) in RPCG than C heifers on d 28 and d 60. A treatment \times breed interaction ($P < 0.01$) occurred for cholesterol, and both Angus and PH heifers fed RPCG had greater ($P < 0.01$) cholesterol than C heifers. Cholesterol was greater ($P < 0.05$) for PH heifers than Angus heifers on the RPCG treatment. The overall effect of feeding RPCG was that it increased serum

cholesterol in heifers, with the greatest effect occurring in PH heifers.

Serum triglycerides were affected by a treatment \times date interaction (Table 3; $P < 0.01$), with similar triglyceride concentrations on d 1 for C and RPCG. Triglycerides in C heifers declined slightly ($P < 0.10$) from d 1 to d 28, but then returned to d 1 values by d 60. The RPCG heifers had increased ($P < 0.01$) triglycerides on d 28, which were also greater ($P < 0.01$) than concentrations in C heifers for that date. On d 60, triglycerides were similar for C and RPCG treatments. In addition to these effects, heifer breed affected ($P < 0.01$) triglyceride concentrations with higher values in Angus heifers (Angus vs. PH, 39.6 vs. 30.7 mg/dl; $P < 0.01$).

A similar pattern was observed for serum HDL and LDL in heifers over time, because LDL was derived from serum cholesterol and HDL. While concentrations of HDL and LDL were each similar for C and RPCG heifers on d 1 (Table 3), both HDL and LDL were greater ($P < 0.01$) at d 28 and d 60 for RPCG than C heifers, and treatment \times date interactions ($P < 0.01$) were observed. The HDL and LDL concentrations decreased ($P < 0.01$) for C on d 28 compared with d 1, but HDL and LDL were greater ($P < 0.01$) for C on d 60 than d 1. At the same time, RPCG heifers had greater ($P < 0.01$) HDL and LDL on both d 28 and d 60 than on d 1. The HDL concentrations were affected by a treatment \times breed interaction ($P < 0.05$), with greater ($P < 0.01$) HDL in both Angus and PH heifers on RPCG compared with C. The Angus and PH heifers had similar HDL on C, but the PH heifers on MCG had greater ($P < 0.05$) HDL than Angus heifers.

Our observed differences for cholesterol, LDL, HDL and triglycerides between C and RPCG heifers (Table 3), were supported by other studies in which rumen-protected fat in the form of Megalac was fed (Hawkins et al., 1995 and Spicer et al., 1993). Our study, however, is the first to report increased concentrations of all four blood lipids when a rumen-protected fat source was fed with CGF. Sklan et al., (1994) reported no difference in cholesterol concentrations between control and experimental treatments when feeding 2.5% rumen-protected fat in a total mixed ration. The reason for the increased cholesterol in the present study might be related to increased dietary fat from rumen-protected fat and CGF supplement, and reproductive state of cattle compared with other research. Hawkins et al. (1995) suggested that increased cholesterol might result from slowed clearance of progesterone, a major product of cholesterol. However the diet may be the most likely source of increased cholesterol, either directly, or through increased levels of acetyl CoA, the substrate of cholesterol genesis. In the present study, an increase in triglycerides was observed, which is supported by Sklan et al. (1994), who fed both primiparous and multiparous dairy cows 2.5% calcium salts of fatty acids (CSFA) as part of a total mixed ration. However, Sklan and Tinsky (1993) fed rumen-protected fat at 4% of the diet to multiparous dairy cows, and they reported no differences in triglycerides. The increase in HDL observed in our study agrees with research by Hawkins et al. (1995) who fed rumen-protected fat (Megalac®, 0.57 kg/heifer daily) in a complete feed of corn silage and alfalfa hay. Other literature did not report increased LDL associated with the feeding of CSFA. However, Hawkins et al. (1995) reported a trend for increased LDL in heifers. In our study this probably resulted from feeding rumen-protected fat as a part of a supplement to heifers on pasture, while Hawkins et al.

(1995) fed the product as part of a complete feed, and they fed CSFA (Megalac®) before and after parturition. Differences in response to rumen-protected fat feeding in these studies could reflect difference in levels of CSFA fed, along with differences in dietary composition, and age and parity of the cows.

Serum leptin concentrations were affected by a treatment \times sampling date interaction (Table 3; Figure 1; $P < 0.05$). Leptin concentrations were similar for C and RPCG heifers on d 1, and leptin in C heifers tended to decline between d 1 and d 28. Leptin increased ($P < 0.01$) in heifers fed RPCG from d 1 to d 28, and it was greater ($P < 0.05$) in RPCG heifers than C heifers on d 60. Leptin was similar on d 1 and d 60 in C heifers, but it was greater ($P < 0.01$) in RPCG heifers on d 60 than d 1. Serum leptin concentrations on d 60 (April 11) at the end of the prebreeding interval were correlated ($R^2 = 0.495$) with the USF measurements ($P < 0.01$). Leptin concentration was not correlated with pregnancy rate ($R^2 = 0.115$; $P > 0.45$).

Leptin is a protein hormone that is synthesized in the adipose tissue. Our study presented the first report of leptin concentrations in serum of heifers on pasture supplemented with rumen-protected fat and CGF. Few reports are available to evaluate the effects of energy and fat supplementation of heifers on leptin concentrations in blood. In one report, as heifer BW increased blood leptin concentrations also increased, especially for pre-pubertal heifers (Garcia et al., 2002). However, this did not explain differences in leptin concentrations observed between treatment groups in our study, because heifer BW and USF were similar, especially at the end of supplementation, at the time when the largest difference in leptin concentrations were observed. Increased leptin concentrations in RPCG heifers possibly resulted from increased energy intake provided by rumen-protected fat and the CGF in the supplement, which agrees with other research that has shown increased leptin concentrations in cattle fed supplemental energy sources (Ehrhardt et al., 2000 and Lents et al., 2005). The C and RPCG heifers had similar BCS and BW at the end of supplementation period (Table 2), which would have been expected to be different if the energy status was different for the two groups. The heifer USF on d 60 did not reveal any differences between treatments (Table 2); however, leptin was correlated with the USF on d 60 (Table 3). A puzzling issue remains regarding reasons for the tendency for leptin to differ while USF measurements did not differ. Ciccioli et al. (2003) reported an increase in leptin resulting from feeding a high nutrient level during the postpartum period in primiparous cows. Using mature beef cows, Lents et al. (2005) concluded that amount of nutrient intake had a greater effect than body energy reserves on insulin and leptin concentrations in plasma of gestating beef cows. Alternatively, ultrasonic determination of fat depth over the ribs may not adequately represent total fat deposits in beef heifers.

The pregnancy data for heifers (C: A 64 %, PH 35 %; RPCG: A 93 %, PH 77 %) show treatment and breed effects, with Angus heifers having greater ($P < 0.05$) pregnancy rates than PH heifers. A trend for increased pregnancy rates was observed for heifers fed RPCG (C vs. RPCG, 56.2 vs. 79.2; $P > 0.10$), and there was no treatment \times breed interaction ($P < 0.63$) for pregnancy rate. Treatments did not affect estimated days pregnant at time of pregnancy examination of heifers (C = 104.5 d; and RPCG = 113.1 d;

$P > 0.10$), but the number of days pregnant at the time of palpation was greater for Angus than PH heifers (Angus vs. PH, 130.4 d vs. 102.3 d; $P < 0.05$). It appeared that feeding RPCG tended to increase ($P > 0.10$) pregnancy rates in PH heifers to a greater extent than in Angus heifers. When the estimated age of fetus at time of pregnancy examination was analyzed, fetal age was approximately 9 d older for RPCG than C heifers. Apparently more heifers tended ($P < 0.10$) to conceive during the 44-d AI interval on RPCG than C, and more ($P < 0.05$) Angus than PH heifers conceived during the AI interval. Over time, more heifers were pregnant on the RPCG treatment, and more Angus than PH heifers conceived after the AI interval.

Trends for increased pregnancy rates and for more heifers conceiving to AI earlier in the breeding interval on RPCG indicate positive reproductive potential of feeding this supplement during the prebreeding interval. The trend for higher pregnancy rates for RPCG heifers in our study was supported by Sklan and Moallem (1991) and Ferguson et al. (1990). However, there have been other reports of no differences in pregnancy rates when CSFA were fed (Sklan and Tinsky, 1993 and Filley et al., 2000). In addition to these differences in pregnancy rate responses to CSFA feeding, differences also exist between studies when observing first service and later service conception rates. Ferguson et al. (1990) and Sklan and Tinsky (1993) reported a higher conception rate at the first service than the second service, while Sklan and Moallem (1991) and Sklan et al. (1994) reported the opposite observation. In the present study, conception rates increased for the first AI service based on the older estimated ages of the fetus for heifers fed the RPCG supplement.

CONCLUSION

Feeding a supplement composed of rumen-protected fat (Megalac®) mixed with corn gluten feed during the prebreeding interval to beef heifers resulted in similar BUN, and increased concentrations of serum cholesterol, triglycerides, and both low-density and high-density lipoproteins. Feeding the supplement increased serum leptin concentrations by the end of the prebreeding interval, and it tended to increase reproductive performance. A higher percentage of heifers fed the supplement conceived during the 44-d AI interval than Control heifers, and supplemented heifers tended to have increased pregnancy rates. Increased serum lipids in supplemented heifers were not reflected in gain performance or ultrasonic rib fat depth. Serum leptin was correlated with ultrasound fat thickness at the end of the prebreeding period. Feeding a supplement that contained rumen-protected fat and corn gluten feed to heifers on pasture before the breeding interval improved reproductive performance, and increased serum lipids, including leptin.

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Table 1. Chemical composition of hay, corn gluten feed, and sod-seeded ryegrass pastures grazed by heifers during the prebreeding interval.

Item	Hay	Corn gluten feed	Pasture 1, d 18 ^a	Pasture 2, d 18 ^a	Pasture 1, d 47 ^a	Pasture 2, d 47 ^a
	----- DM basis, % -----					
DM	88.6	87.9	92.3	92.6	92.1	92.3
CP	14.2	23.4	31.1	32.4	16.3	18.3
ADF	39.5	11.6	24.6	24.7	26.3	27.1
NDF	70.9	32.3	50.1	49.1	45.6	45.5
TDN	56.0	74.0	65.0	65.0	69.0	69.0
	----- Mcal/kg -----					
NE _m	0.48	0.77	0.64	0.65	0.72	0.72

^aPastures during experimental period consisted of dormant Coastal bermudagrass with sod-seeded with ryegrass.

Table 2. Effects of feeding a rumen-protected fat and corn gluten feed (RPCG) supplement on least square means for BW, BCS and ultrasound rib fat (USF) depth of heifers^a.

Item	Control	RPCG ^a	SE	Angus	PH ^b	SE
No. heifers	20	21		24	17	
BW	----- kg -----					
d 1	376.5	373.2	6.4	386.4 ^y	363.2 ^z	6.4
d 28	404.7 ^z	410.8 ^y	2.0	408.3	407.2	2.2
d 60	430.7	434.4	2.9	435.6	429.5	3.1
d 106	442.2	444.5	3.1	446.8	439.8	3.3
d 128	444.2	445.6	3.2	444.2	445.6	3.4
d 133	453.7	458.2	3.2	459.9	452.0	3.5
d 218	483.0	483.7	4.2	488.4	478.2	4.4
BCS ^c	----- BCS scale -----					
d 1	5.2	5.2	0.14	5.1	5.3	0.14
d 28	5.6 ^z	5.8 ^y	0.13	5.5 ^z	5.8 ^y	0.13
d 60	4.9	5.0	0.15	5.0	5.0	0.15
d 106	4.8	4.8	0.13	4.8	4.9	0.13
d 128	4.7	4.8	0.14	4.7	4.9	0.14
USF	----- cm -----					
d 1	2.2	2.1	0.2	2.0 ^z	2.3 ^y	0.2
d 60	2.2	2.4	0.2	2.2	2.4	0.2
d 128	2.2	2.2	0.2	2.2	2.2	0.2

^a RPCG = Rumen protected fat (Megalac®) and corn gluten feed;

^bPH=Polled Hereford;

^cScale for BCS (1 = emaciated; 5 = normal flesh; 9 = obese).

^{y,z}Means within treatment or heifer breed comparisons bearing different superscript letters are different ($P < 0.05$).

Table 3. Rumen-protected fat and corn gluten feed (RPCG) supplementation effects on treatment least square means of serum components in heifers at three sampling dates before the breeding period.

Item	Control	RPCG	SE
No. heifers	20	21	
	-----mg/dl-----		
BUN ^a			
d 1	22.5	22.2	
d 28	25.9	23.2	0.61
Cholesterol ^a			
d 1	121.6	123.6	
d 28	108.3 ^x	175.2 ^w	
d 60	139.6 ^x	162.9 ^w	4.53
Triglycerides ^a			
d 1	34.2	34.4	
d 28	30.8 ^x	40.5 ^w	
d 60	34.2	37.0	1.39
HDL ^{ab}			
d 1	95.1	96.9	
d 28	78.3 ^x	130.2 ^w	
d 60	100.9 ^x	122.2 ^w	3.77
LDL ^a			
d 1	19.4	19.8	
d 28	23.6 ^x	37.0 ^w	
d 60	31.9	33.2	0.96
	----- ng/mL -----		
Leptin ^c			
d 1	8.3	8.2	
d 28	7.5	9.1	
d 60	8.4 ^z	10.7 ^y	0.53

^aTreatment x sampling date interaction (P < 0.01).

^bHDL = high-density lipoprotein; LDL = low-density lipoprotein.

^cTreatment x sampling date interaction (P < 0.05).

^{wx}Means on same line bearing different superscript letters are different (P < 0.01).

^{yz}Means on same line bearing different superscript letters are different (P < 0.05).