Effect of forage species and supplement type on rumen kinetics and serum metabolites in growing beef heifers grazing winter forage[1]

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ABSTRACT: The objective of this study was to determine the effect of stockpiled forage type and protein supplementation on VFA production, serum metabolites, and BW in yearling beef heifers. Over 2 yr, spring-born, Angus crossbred yearling beef heifers (n = 42; 305 ± 2.9 kg initial BW) were randomly assigned to 1 of 3 forage pasture types: 1) endophyte-infected tall fescue [TF; *Schedonorus arundinaceus* (Schreb.) Dumort], 2) a big bluestem (*Andropogon gerardii* Vitman) and indiangrass (*Sorghastrum nutans* L.) combination (BI), or 3) switchgrass (SG; *Panicum virgatum* L.). Each pasture was then randomly assigned to receive either 1 of 2 isonitrogenous CP treatments: 1) 0.68 kg·heifer^{-1}·d^{-1} of dried distiller's grains with solubles (DDGS; 28% CP and 88% TDN) or 2) 0.22 kg·heifer^{-1}·d^{-1} of blood meal and fish meal (BF; 72.5% CP and 69.5% TDN), resulting in a 3 × 2 factorial arrangement of treatments. Treatments were initiated in January and terminated in April in both years of the study. Body weights and blood samples were collected approximately every 28 d from initiation of grazing until the end of the trial. Heifer BW change from January to February and overall BW change were greater (P < 0.01) for TF heifers. However, BW change from March to April was not different (P = 0.84) among forage types. Supplement type did not influence ($P \geq 0.13$) BW or BW change from January to February and from January to April; however, heifers fed DDGS had greater (P = 0.03) BW gain from March to April. Heifer BW change from February to March exhibited (P < 0.05) a forage type × supplement interaction, with BF-fed heifers gaining more BW on BI pastures than DDGS-fed heifers. Serum glucose concentrations, ruminal acetate, and the acetate:propionate ratio were greater ($P \leq 0.04$) for SG heifers. However, circulating serum NEFA and urea N (SUN) concentrations were not different ($P \geq 0.85$) among forage types. Serum glucose and NEFA concentrations were not influenced ($P \geq 0.61$) by supplement type. Circulating SUN concentrations were greater (P < 0.01) in BF-supplemented heifers. Ruminal acetate tended to be greater (P = 0.09) and butyrate concentrations were greater (P < 0.01) for BF-supplemented heifers. The acetate:propionate ratio was not influenced (P = 0.15) by supplement type. These results suggest that a compensatory gain period prior to breeding would be needed for these native warm-season species to be a viable opportunity for growing and developing replacement heifers in the southeastern United States.

Key words: beef heifer, protein supplementation, winter grazing

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INTRODUCTION

Development of replacement females contributes a significant expense to beef producers due to feed costs and innate opportunity costs. The primary cost of developing heifers is the supplemental feed required to reach sufficient gains to attain puberty

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before breeding (Roberts et al., 2009). As such, implementing strategies to achieve production goals while minimizing input costs can enhance production practices. Therefore, extending grazing through the winter using stockpiled cool- or warm-season forages with supplementation may be an economical alternative to feeding harvested feedstuffs. Different growing seasons of cool- and warm-season forages have allowed for management systems to implement sequential grazing to extend the grazing season (Moore et al., 2004). Stockpiling forages does increase the total herbage mass available for grazing; however, forage nutritive value is reduced in response to increased forage maturity (Wheeler et al., 2002). Therefore, a concern with stockpiled forages in heifer development systems is that BW gain may be inadequate for heifers to attain 60 to 65% of mature BW prior to breeding (Poore et al., 2006). However, Funston and Deutscher (2004) reported that developing heifers to a lower target BW (approximately 55% mature BW) reduced input costs without impairing reproductive function or subsequent calf performance. Supplementing beef heifers with high-RUP supplements has increased ADG and energy utilization of low-quality native forages (Lalman et al., 1993). Furthermore, supplementing low quantities of a high-RUP supplement (40 g/d of CP) may potentially replace greater quantities (160 g/d of CP) while maintaining rumen function (Sawyer et al., 2012). In addition, heifers grazing low-quality dormant range and fed a high-RUP supplement had increased ADG during breeding, pregnancy rates, and longevity compared with those fed a lower-RUP plant-based supplement (Mulliniks et al., 2013). Therefore, our objective was to determine the effect of stockpiled winter forage type and protein supplementation strategy on VFA production, serum metabolites, and heifer BW and BW change.

MATERIAL AND METHODS

All animal handling and experimental procedures were conducted according to the guidelines of the Institutional Animal Care and Use Committee (**IACUC**) of the University of Tennessee (IACUC approval number 2146-0116).

Animals and Treatments

In a 2-yr study, 42 spring-born, crossbred Angus heifers (305 ± 2.9 kg initial BW) were used to determine the effect of winter grazing stockpiled forage types and protein supplementation strategy on growth, VFA production, and serum metabolites. Heifers were managed together before and after the grazing trial. This research was conducted at the Middle Tennessee Research & Education Center, Spring Hill, TN (35°43′7.3056″ N, 86°57′54.7884″ W), from January 9, 2014, to March 31, 2014, and from January 5, 2015, to March 30, 2015. Average annual precipitation at this location was 1,475 mm. Heifers were stratified by BW to 1 of 3 stockpiled forage types (7 replicates per forage treatment; 1.2-ha pastures) and received either 1 of 2 protein supplements at weaning in a 3 × 2 factorial arrangement. One heifer was randomly assigned to each pasture. Stockpiled forages were 1) toxic endophyte-infected tall fescue (**TF**; *Schedonorus arundinaceus* (Schreb.) Dumort, cool-season forage), 2) big bluestem (*Andropogon gerardii* Vitman) and indiangrass (*Sorghastrum nutans* L.) combination (**BI**; warm-season forage), or 3) switchgrass (**SG**; *Panicum virgatum* L.; warm-season forage). Each forage type was randomly assigned to receive either 1 of 2 supplement types: 1) 0.68 kg·heifer^{-1}·d^{-1} of dried distiller's grains with solubles (**DDGS**; 28% CP, 74% RUP, and 88% TDN on a DM basis) or 2) 0.22 kg·heifer−1·d−1 of blood meal and fish meal (**BF**; 72.5% CP, 67.5% RUP, and 69.5% TDN on a DM basis). Samples were analyzed by a commercial laboratory (Rock River Laboratory, Inc., Watertown, WI). Supplements were provided twice weekly at approximately 0800 h. An adaptation period for the BF supplement occurred over a 2-wk period prior to the start of the study. The BF supplement was mixed at a 50:50 and 75:25 ratio with DDGS for the first and second week, respectively, of the adaptation period. Feed refusals were not recorded because all supplement in both treatment groups was completely consumed.

Forage Treatments and Measurements

Summer grazing of all pastures was terminated in late August prior to the initiation of stockpiling. Forages were stockpiled beginning the first day of September prior to each year of the study with no added fertilizer. Pastures were under continuous grazing management during the grazing trial. The warm-season forage cultivars were Alamo SG and a mixture (1:1 based on seed mass) of big bluestem and indiangrass ecotypes (Roundstone Native Seed, LLC, Upton, KY) for SG and BI pastures, respectively (Keyser et al., 2016). Warm-season forage pastures were established in 2008. A complete description of the pasture establishment procedures is discussed by Keyser et al. (2016).

To estimate the forage mass in each year, 10 samples per pasture (1.2 ha per pasture) were collected at the initiation (January 9, 2014, and January 5, 2015) and at the end of the study (March 31, 2014, and March 30, 2015) using a 0.1-m^2 frame at 5 cm residual height. Additionally, a forage sample from the midpoint of grazing (February 17, 2014, and February 13, 2015)

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was hand-plucked from each pasture for nutritive quality analysis. All sampling was randomly conducted in a Z-shaped pattern. Samples were analyzed for DM, ash, CP, and NDF content. The DM content of the samples was determined by drying at 55°C in a forced-air oven for 48 h. Samples were then lyophilized and ground through a 2-mm screen using a Wiley mill (Thomas Scientific, Swedesboro, NJ). Dry matter and OM were determined according to procedures published by the Association of Official Analytical Chemists (1990; methods DM (934.01) and OM (942.05), respectively). Crude protein was determined by total N combustion analysis (Leco-NS2000 [LECO Corp., St. Joseph, MI]; method 976.06 [Horwitz, 2000]). Neutral detergent fiber content was assessed using the ANKOM 200 fiber analysis system (ANKOM Technology Corp., Fairport, NY).

Animal Measurements

All samples were collected at approximately 0900 h for every sampling period. Heifer BW and BCS (1 = emaciated and 9 = obese; Wagner et al., 1988) were recorded at the initiation of the study and ascertained approximately every 28 d. Heifer BW was an unshrunk BW made using the weighing facilities in the center of the paddocks. At the same time, approximately 30 mL of rumen fluid was sampled with an oral lavage. Samples were stored in 15-mL polypropylene conical tubes at −20°C until analysis of VFA. Volatile fatty acid concentration was determined by gas chromatography. Rumen samples were prepared by centrifuging strained samples at 10,000 × *g* for 10 min at 4°C. A mixture of 5 mL of ruminal fluid supernatant and 1 mL of meta-phosphoric acid–2-ethylbutyric acid solution was then prepared. This mixture was allowed to stand in an ice bath for ≥30 min and then prepared for a second centrifuge for 10 min at 10,000 × *g* and 4°C. The samples were then analyzed using a gas chromatograph (GC-2010; Shimadzu Corp., Kyoto, Japan) with a previously described method (Erwin et al., 1961). Blood samples were collected monthly into serum separator tubes via coccygeal venipuncture (approximately 9 mL; Monoject Corvac, Sherwood Medical Co., St. Louis, MO. Blood samples were cooled and centrifuged at 2,000 × *g* at 4°C for 20 min. Serum was separated and stored in plastic vials at −20°C until further analysis. Serum samples were analyzed for glucose, NEFA, and urea N (**SUN**). Serum samples were analyzed using a 96-well microplate reader spectrophotometer with commercial kits for NEFA (Wako Chemicals USA, Inc., Richmond, VA; sensitivity of 0.01 mmol/L), glucose (Thermo Electron Corp., Waltham, MA; sensitivity of 0.3 mg/dL), and SUN (Thermo Electron Corp.; sensitivity of 2.0 mg/dL). The intra- and interassay CV were 4.26 and 4.58%, respectively, for serum NEFA, 5.83 and 4.85%, respectively, for serum glucose, and 2.17 and 1.81%, respectively, for SUN.

Statistical Analysis

Normality of the data distribution and equality of variances of measurements were evaluated using PROC UNIVARIATE. Data were analyzed as a complete randomized design, using a mixed procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) using the Kenward–Roger degrees of freedom method and pasture as the experimental unit. The model for rumen fermentation parameters, serum metabolites, and heifer performance data included fixed effects of forage type, supplement type, year, and their interactions. Repeated measures was used for variables collected over time, with sampling period as the repeated factor and compound symmetry as the covariance structure as determined using Akaike's information criterion. Forage mass and chemical composition analyses were performed including fixed effects of year, month, forage type, and their interactions. The LSMEANS option was used to calculate treatment means, and the PDIFF statement was used for the separation of main effects and any interactions. Least squares means were compared using Fisher's LSD at a significance level of $P \leq 0.05$. Tendencies were determined at $0.10 \geq P > 0.05$. Data were presented as main effects if interactions were not determined.

RESULTS AND DISCUSSION

Forage Characteristics

Typically, in the southeastern United States, stockpiled TF is an economically viable winter forage source for growing cattle (Drewnoski et al., 2009). Warm-season grasses have been used to complement grazing of cool-season grasses, especially in TF systems, during their senescence in summer (Hudson et al., 2010). Warm-season grasses are characterized by their high productivity, drought tolerance, and efficient use of N in warm temperatures (Sage and Kubien, 2003). Therefore, due to their high productivity, stockpiling native warm-season forages for winter grazing may offer another winter grazing opportunity. In the current study, forage mass exhibited ($P < 0.01$; Table 1) a forage type × grazing period interaction. Forage mass of BI and SG pastures was greater ($P \leq 0.02$) at grazing termination in April compared with forage mass in January. However, forage mass at the beginning and end of grazing was not different ($P = 0.16$) in TF pastures. Warm-season forages have decreased nutritive value and digestibility during senescence (Reid et al., 1988). Therefore, differences in forage growing season and intake of warm-season grass-

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Table 1. Forage type and grazing period effects on forage characteristics of stockpiled winter forages from beginning to end of the grazing period

	Treatment[1]			
Measurement	TF	BI	SG	SEM
Forage mass, kg DM/ha				
January	1,225.01^{ax}	1,784.44^{bx}	1,229.72^{cx}	106.14
April	1,029.39^{ax}	2,149.14^{by}	1,657.92^{cy}	103.45
CP, %				
January	8.66^{ax}	5.06^{bx}	3.82^{cx}	0.37
February	7.65^{ay}	4.25^{bx}	3.83^{bx}	0.37
April	9.40^{ax}	4.75^{bx}	3.40^{cx}	0.37
NDF, %				
January	61.64^{ax}	69.09^{bx}	76.78^{cx}	0.81
February	68.28^{ay}	72.21^{by}	77.99^{cx}	0.81
April	65.55^{az}	68.85^{bx}	77.21^{cx}	0.81

$^{a–c}$Within a forage type, means with different superscripts differ ($P < 0.05$).

$^{x–z}$Within a grazing period, means with different superscripts differ ($P < 0.05$).

[1]Forage: endophyte-infected tall fescue (TF), big bluestem and indiangrass combination (BI), and switchgrass (SG).

Table 2. Forage type effects on beef heifer performance during the winter grazing period in Tennessee

	Forage[1]				
Measurement	TF	BI	SG	SEM	*P*-value
Heifer BW, kg					
January	301	306	307	3	0.27
February	318^{a}	292^{b}	288^{b}	4	<0.01
March	326^{a}	292^{b}	281^{b}	5	<0.01
April	335^{a}	302^{b}	289^{c}	5	<0.01
BW change, kg					
January to February	17^{a}	−13^{b}	−18^{b}	4	<0.01
March to April	9	9	7	2	0.84
January to April	34^{a}	−4^{b}	−18^{c}	4	<0.01
BCS					
January	5.77	5.70	5.85	0.05	0.12
February	5.26	5.19	5.26	0.04	0.39
March	5.25^{a}	4.98^{b}	4.90^{b}	0.07	<0.01
April	5.23^{a}	5.00^{b}	4.86^{b}	0.08	<0.01

$^{a–c}$Means with different superscripts differ ($P < 0.05$).

[1]Forage: endophyte-infected tall fescue (TF), big bluestem and indiangrass combination (BI), and switchgrass (SG).

es due to nutrient quality (Vona et al., 1984) may account for forage mass differences at grazing termination.

Crude protein exhibited ($P < 0.01$; Table 1) a forage type × grazing period interaction. During the entire grazing study, TF pastures had greater ($P < 0.01$) CP levels than BI or SG pastures. No differences ($P = 0.31$) in CP content were detected between the 2 warm-season grasses in February; however, in April, SG pastures had lower ($P < 0.01$) CP content compared with their warm-season forage counterpart of BI pastures. Additionally, a forage type × grazing period interaction was exhibited ($P < 0.01$) for NDF content. Over the grazing period, TF pastures had lower ($P < 0.01$) NDF content than warm-season grasses. However, from January to February, NDF content increased ($P < 0.01$) for TF and BI pastures, with no differences ($P \geq 0.27$) for SG pastures during the entire grazing period. In the southeastern United States, TF starts to accumulate more green tissue and increase CP levels in late February (Poore et al., 2006). In contrast, warm-season forages typically completely senesce in October and begin growing in late March with a rapid growth period starting in late April in Tennessee (Keyser et al., 2012). Therefore, CP content of native warm-season forages declines and NDF content increases during winter dormancy (Brandyberry et al., 1991). As expected, TF pastures had greater nutrient quality than warm-season forages during the entire study.

Animal Performance

Heifer BW did not exhibit ($P \geq 0.28$) a forage type × supplement type interaction during the grazing period. Initial BW in January was not different ($P = 0.27$; Table 2) among heifers grazing the different forage types. However, heifer BW from February to April was greater ($P < 0.01$) for heifers grazing TF pastures than their counterparts. At the end of the grazing trial, heifers grazing SG pastures had the lowest ($P < 0.01$) BW compared with heifers grazing counterpart forage treatments. From January to February, heifers grazing TF pastures gained ($P < 0.01$) BW whereas BI and SG heifers lost not different ($P = 0.35$) amounts of BW. From March to April, forage type did not influence ($P = 0.84$) heifer BW change. Overall BW gain from January to April was greater ($P < 0.01$) in heifers grazing TF pastures than in BI and SG heifers. Body condition score was not influenced ($P \geq 0.12$) by forage type in January or February. Due to differences in BW change, heifers grazing TF pastures had greater ($P < 0.01$) BCS than their counterparts in March and April. As expected, heifers grazing TF had greater BW gain and BCS compared with heifers grazing warm-season grasses. Heifers grazing BI and SG pastures initially lost BW from January to February; however, heifers grazing the native warm-season forage may have decreased their maintenance requirements, resulting in no difference in BW gain compared with TF heifers from March to April. Similarly, developing heifers on low-quality forages has been shown to improve the efficiency of nutrient utilization by lowering maintenance requirements (Freetly et al., 2008).

Heifer BW was not influenced ($P \geq 0.13$; Table 3) by supplement type during the duration of the study. In addition, heifer BW change was not different ($P \geq 0.13$) from January to February and from January to April. However, heifers fed DDGS from March to April did

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Table 3. Supplement type effects on beef heifer performance during the winter grazing period in Tennessee

	Supplement[1]			
Measurement	BF	DDGS	SEM	*P*-value
Heifer BW, kg				
January	302	307	2	0.13
February	300	299	3	0.80
March	301	298	4	0.61
April	307	310	4	0.60
BW change, kg				
January to February	−2	−8	4	0.13
March to April	5	12	2	0.03
January to April	5	3	3	0.69
BCS				
January	5.77	5.77	0.04	0.98
February	5.24	5.19	0.03	0.27
March	5.09	4.89	0.06	0.25
April	5.04	5.02	0.06	0.85

[1]Supplement: blood meal and fish meal (BF) and dried distiller's grains with solubles (DDGS).

Table 4. Forage type and supplement type effects (forage type × supplement type) on beef heifer production during the winter grazing period in Tennessee

	Forage[1]			
Measurement	TF	BI	SG	SEM
February to March[2] BW change, kg				
BF	7^{ax}	5^{ax}	-9^{bx}	2
DDGS	8^{ax}	-5^{by}	-6^{bx}	3

[a,b]Within a forage, means with different superscripts differ ($P < 0.05$).

[x,y]Within a supplement, means with different superscripts differ ($P < 0.05$).

[1]Forage: endophyte-infected tall fescue (TF), big bluestem and indiangrass combination (BI), and switchgrass (SG).

[2]Supplement: blood meal and fish meal (BF) and dried distiller's grains with solubles (DDGS).

gain ($P = 0.03$) more BW than heifers fed BF. Feeding DDGS to growing cattle consuming forage-based diets provides energy in the form of highly digestible fiber and fat (Stock et al., 2000). However, more frequent DDGS supplementation may be required for improvement in animal growth (Stalker et al., 2009). From February to March, BW change exhibited ($P < 0.01$; Table 4) a forage type × supplement type interaction. Supplement type did not influence ($P \geq 0.26$) heifer BW change in heifers grazing TF or SG pastures; however, heifers fed BF outgained ($P < 0.01$) heifers fed DDGS while grazing BI pastures. Body condition scores during this study were not different ($P \geq 0.25$) between heifers fed DDGS and heifers fed BF. Lalman et al. (1993) reported no difference in BW and ADG in heifers during supplementation of RUP, propionic acid, or monensin. Likewise, heifers provided with isonitrogenous (36% CP) supplements containing either 36 or 50% RUP exhibited no difference in BW and ADG over the course of the study (Mulliniks et al., 2013). Overall, the 2 different protein supplements had little impact on BW and BW change in the present study.

Serum Metabolites

Serum metabolites did not exhibit ($P \geq 0.30$) a forage type × sampling time or supplement type × sampling time interaction. Serum glucose concentrations were greater ($P = 0.02$; Table 5) in heifers grazing SG pasture than in their counterparts. Circulating concentrations of NEFA were not different ($P = 0.88$) among forage types. Elevated NEFA concentrations were expected in heifers grazing warm-season grasses, as indicated by the BW change differences. However, heifers grazing warm-season grasses did have an increased BW gain prior to the end of the grazing trial. Concentrations of NEFA can rapidly decline as animals experience a compensatory growth period (Ellenberger et al., 1989). Additionally, heifers fed to maintain BW for 95 d had decreased circulating NEFA concentrations within 10 d of realimentation to levels not different from ad libitum–fed heifers (Yambayamba et al., 1996). Serum urea N concentrations were not different ($P = 0.85$) among forage types. Differences in circulating SUN were expected due to forage quality differences and BW losses in heifers grazing SG and BI pastures. However, heifers grazing TF had lower SUN concentrations than expected with regard to forage nutrient value (Poore et al., 2006; Drewnoski et al., 2009; Lyons et al., 2016). Collectively, these authors suggest that intake of degradable protein may be limiting growth performance in heifers grazing TF (Poore et al., 2006; Drewnoski et al., 2009; Lyons et al., 2016). Concentrations of SUN can provide an indication of N availability resulting from deamination of dietary and endogenous protein sources (Roseler et al., 1993). Ruminal N recycling may preserve dietary N in response to nutrient restriction (Bunting et al., 1989), and compensatory gain following nutrient restriction may improve metabolic and N efficiency (Freetly and Nienaber, 1998).

Serum glucose concentrations were not different ($P = 0.70$; Table 6) between protein supplement types. Heifers fed BF had greater ($P < 0.01$) circulating concentrations of SUN than their counterparts. In the present study, heifers were supplemented with not different amounts of CP; however, BF supplementation increased SUN concentration. Excess AA are catabolized to urea by the liver (Drackley et al., 2001), which results in increased circulating SUN. Slowly fermented forages require less RDP because excess degradable protein may cause N losses from the rumen and may decrease N recycling (Siddons et al., 1985). Supplement type did not influence ($P = 0.61$) serum NEFA concentration, which was expected due to minimal BW change differences.

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Table 5. Forage type effects on serum metabolites and VFA profile of beef heifers during the winter grazing period in Tennessee

	Forage[1]				
Measurement	TF	BI	SG	SEM	*P*-value
Serum metabolites					
Glucose, mg/dL	73.2[a]	69.0[a]	84.2[b]	4.06	0.02
NEFA, mmol/L	356.0	343.8	358.8	24.65	0.88
SUN,[2] mg/dL	10.03	9.85	9.61	0.59	0.85
Rumen VFA					
Acetate	43.6[a]	42.8[a]	52.6[b]	2.92	0.04
Propionate	10.9	10.8	12.0	0.64	0.32
Butyrate	6.8	5.7	7.5	0.91	0.33
Acetate:propionate ratio	4.1[a]	4.0[a]	4.5[b]	0.14	0.04

[a,b]Means with different superscripts differ ($P < 0.05$).

[1]Forage: endophyte-infected tall fescue (TF), big bluestem and indiangrass combination (BI), and switchgrass (SG).

[2]SUN = serum urea N.

Table 6. Supplement type effects on serum metabolites and VFA profile of beef heifers during the winter grazing period in Tennessee

	Treatment[1]			
Measurement	BF	DDGS	SEM	*P*-value
Serum metabolites				
Glucose, mg/dL	76.3	74.9	3.26	0.70
NEFA, mmol/L	359.2	346.5	19.75	0.61
SUN,[2] mg/dL	10.9	8.7	0.48	<0.01
Rumen VFA				
Acetate	49.1	43.6	2.19	0.09
Propionate	11.5	10.9	0.50	0.40
Butyrate	8.2	5.2	0.64	<0.01
Acetate:propionate ratio	4.3	4.1	0.11	0.15

[1]Supplement: blood meal and fish meal (BF) and dried distiller's grains with solubles (DDGS).

[2]SUN = serum urea N.

Volatile Fatty Acid Production

All VFA concentrations did not exhibit ($P \geq 0.57$) an interaction for either forage type × sampling time or supplementation type × sampling time. Heifers grazing SG pastures had greater ($P = 0.04$; Table 5) ruminal acetate concentrations than their counterparts. However, ruminal concentrations of propionate and butyrate were not influenced ($P \geq 0.32$) by forage species. Due to an increase in ruminal acetate concentration, the ruminal acetate:propionate ratio was greater ($P = 0.04$) for heifers grazing SG pastures. Ruminal acetate concentrations increase as plants mature and indicate fermentation of the plant cell wall (McCollum et al., 1985). Typically, warm-season grasses are expected to be lower in nutritional quality (Galyean and Goetsch, 1993). Bohnert et al. (2011) determined that low-quality warm-season forage decreased ruminal retention time and increased digestibility with CP supplementation compared with low-quality cool-season forage. In the present study, SG pastures were lower quality and likely less digestible than BI and TF pastures, leading to subsequent changes in molar VFA concentrations.

Heifers fed BF tended ($P = 0.09$; Table 6) to have a greater ruminal acetate concentration. Ruminal propionate concentration was not influenced ($P = 0.40$) by supplement type. However, the acetate:propionate ratio was not influenced ($P = 0.15$) by supplement type. Furthermore, the ruminal butyrate concentration was greater ($P < 0.01$) in BF-fed heifers than their DDGS-fed counterparts. Protein supplementation of beef cattle consuming low-quality forage has increased forage intake (McCollum and Galyean, 1985). Typically, protein supplementation elicits positive responses when forage CP content is less than 6% (Kartchner, 1980). In addition, Köster et al. (1996) reported that supplemental RDP increased ruminal VFA concentrations and decreased the acetate:propionate ratio. Likewise, supplementation of cottonseed meal decreased the acetate:propionate ratio (McCollum and Galyean, 1985). Ruminal butyrate concentrations were increased in steers grazing low-quality range and provided supplemental protein (Caton et al., 1988). Supplementation of fish meal to lactating dairy cows did not influence ruminal VFA concentrations compared with isonitrogenous corn gluten meal (Spain et al., 1995). Supplementation of BF may have increased forage intake compared with DDGS in the present study. Overall, supplementation of the 2 different high-RUP sources had minimal impact on ruminal fermentation end products.

In conclusion, grazing dormant, native warm-season grasses delayed gain; however, heifers grazing warm-season native forages were on the positive rate of gain by the end of the grazing period. Of the forage types evaluated, only stockpiled switchgrass pastures altered rumen fermentation as a result of forage nutritive value and maturity. However, if using stockpiling warm-season forages for winter grazing is used in heifer development systems, a compensatory gain period may be needed to make these species a viable opportunity for heifers in the southeastern United States.

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