Intake and Digestibility of Bahiagrass Hay by Cattle that are Supplemented with Molasses or Molasses-Urea with or without Soybean Hulls

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ABSTRACT

Two experiments were conducted to evaluate the effect of molasses or molasses-urea supplementation with or without soybean hulls on digestibility, intake, and animal performance in cattle fed bahiagrass (Paspalum notatum Flugge) hay. In Experiment 1, 6 Holstein steers (average BW 256 ± 15 kg) were fed 1 of 6 treatment diets: 1) bahiagrass hay only; 2) hay plus molasses; 3) hay plus molasses-urea; 4) hay plus soybean hulls; 5) hay plus soybean hulls and molasses; and 6) hay plus soybean hulls and molasses-urea. Molasses were fed at 0.59% of BW (DM basis), soybean hulls at 0.75%, and urea at 4.5% of the weight of the molasses. Dry matter intake and apparent digestibility were measured in an incomplete Latin square design with a 28-d recovery period between each period. Digestibility of dietary DM, OM, and ADF was increased with soybean hulls (P < 0.05) supplementation. Molasses supplementation tended to increase (P < 0.10) DM digestibility but decreased digestion of CP (P < 0.10) and fiber (P < 0.01). Addition of urea to molasses increased (P < 0.05) CP and NDF digestion when soybean hulls were absent, but only increased CP digestion (P < 0.05) when soybean hulls were present. Plasma urea nitrogen was increased (P > 0.10) by soybean hulls. Urea added to molasses increased nonesterified fatty acids (P < 0.05) but nonesterified fatty acids and blood glucose was not affected (P > 0.10) by soybean hulls. Soybean hulls may be an effective supplement for increasing average daily gains without decreasing hay intake for cattle fed mature bahiagrass hay, and for molasses to be effective in growing cattle, it should be fortified with a nitrogen source such as urea.

Key words: beef cattle, bahiagrass hay, soybean hulls, molasses-urea, intake, digestibility

INTRODUCTION

Beef cattle operations in the southeastern United States rely on forage-based diets. Unfortunately for many...
producers in this region, particularly those dependent upon bahiagrass, the required forage quality, quantity, or both is limited at certain times of the year. During these times, cattle grazing bahiagrass as the sole diet may not be able to consume sufficient energy to meet the requirements for a preferred level of performance (Moore and Kunkle, 1995). Bahiagrass can also be deficient in RDP (Johnson et al., 2001), causing producers to rely on grain, protein products, or liquid supplements to make up for the nutritional shortfalls.

Cane molasses has been used as a supplement in forage-based diets since the 1950s with success in improving animal performance (Moore et al., 1999). However, it is marginal in nitrogen (about 5 to 6% DM; NRC, 1996) compared with the animal’s requirement and can depress fiber digestibility if dietary CP is low (Heldt et al., 1999a). Urea has been used to alleviate this deficiency (Beams, 1959; Delgado et al., 1978; Moore et al., 1999). Although grains are high in ME, interactions with ruminal microbes may cause a depression in forage digestion (Chase and Hibberd, 1987; Piwonka and Firkins, 1996). Soybean hulls or other fibrous by-products have become commonly used to supplement forage-based diets with increased gains (Anderson et al., 1988; Garces-Yepez et al., 1997) and with a reduced potential to interfere with ruminal digestion (Chase and Hibberd, 1987; Martin and Hibberd, 1990; Garces-Yepez et al., 1997). However, forage intake may be reduced through substitution, especially as soybean hulls are fed at higher levels (Martin and Hibberd, 1990), depending on whether the forage was tropical or temperate (Galloway et al., 1993). The objectives of these studies were to evaluate the added effects of soybean hulls, molasses, and urea on intake and digestibility of bahiagrass hay.

MATERIALS AND METHODS

Two experiments were conducted to evaluate dietary supplements. In both experiments, the treatments were 1) bahiagrass hay only; 2) hay plus molasses at 0.59% of BW; 3) hay plus molasses at 0.59% of BW containing 4.5% urea by weight; 4) hay plus soybean hulls at 0.75% of BW; 5) hay plus soybean hulls at 0.75% of BW and molasses at 0.59% of BW; and 6) hay plus soybean hulls at 0.75% of BW and molasses at 0.59% of BW containing 4.5% urea by weight. Supplement amounts were calculated on a DM basis.

Experiment 1

Three digestion trials were conducted, each with 6 Holstein steers (initial BW 256 ± 15 kg). Animals were randomly assigned to treatments for the first period and rotated among treatments for 2 subsequent periods in an incomplete Latin square design such that each animal received 3 different diets over the experiment. The experiment was conducted at the USDA-ARS Subtropical Agricultural Research Station (STARS) in Brooksville, FL from May 2001 to September 2001. Protocols were approved by the STARS Institutional Animal Care and Use Committee.

The Pensacola bahiagrass hay was grown at the Beef Research Unit at the University of Florida in Gainesville and harvested in September after a full season of growth. To introduce the animals to the hay and to establish the potential intake of each animal, they were individually fed bahiagrass hay ad libitum in outside, individual free-stall pens (8.5 x 13 m) for 28 d prior to the start of each experimental period. Although not the same hay as the experimental hay, it was very similar in quality. During the collection period, the amount of hay offered (for each animal) was set at 90% of potential intake determined from the average intake over the final 2 wk of the adjustment period. Hay and supplement characteristics for the experiment are shown in Table 1. During each of the 3 periods, animals were housed in metabolism crates and had free access to water, salt and a commercial mineral mix.

Each experimental period consisted of 3 wk, and each period was separated by 28 d to reduce carryover effects. The first wk of each period was used for adaptation to digestion stalls and supplemental diets. During the second and third weeks, 2 separate 4-d total collection periods (11 to 14 d and 18 to 21 d, respectively) were conducted, which allowed examination of time effects and of any adaptation response to the supplements. During the 4-d collection period, weights of total feed offered, feed refusal, and feces were recorded daily, and subsamples of each were collected and composited for each animal for the week. Steers were weighed prior to and immediately after each period, and blood samples were collected and composited for each animal at the end of each period. Blood samples were taken by jugular venipuncture prior to the morning feeding of the last day. During the interperiod interval (28 d), steers were removed from the metabolism crates, housed in free-stall pens, and again fed hay similar to the experimental forage.

Feed and fecal samples were freeze-dried (Genesis SQ25, VirTis Co., Gardiner, NY) and subsequently ground with a Wiley mill (Thomas Manufacturing, Philadelphia, PA) to pass through a 1-mm screen. Duplicate samples were analyzed for DM and OM (AOAC, 2000). Nitrogen was determined by the AOAC (2000) semiautomated method 976.06. Neutral-detergent fiber and ADF were determined using a modified Ankom method (Method for Determining NDF, ANKOM Technology, 8/98 and Method for Determining ADF, ANKOM Technology, 9/99; ANKOM Technology, 397 believes no further information is necessary. The modifications included the following: 1) sodium sulfite was not added for the NDF analysis to reduce artifact losses (Van Soest et al., 1991); 2) samples were heated and agitated during the 5-min rinse cycles instead of being agitation only to improve soap removal; and 3) bags were soaked in acetone for 5 min instead of 3 min to facilitate water removal.
Blood samples were collected, immediately placed on ice, and subsequently centrifuged at 1,800 × g, after which plasma was removed and frozen (−20°C) until analyzed. Plasma samples were analyzed for plasma urea nitrogen (PUN) concentration by an automated colorimetric procedure (Technicon Autoanalyzer II, Technicon Instruments Corp., Tarrytown, NY) using the Industrial method No. 339-01 (modification of Marsh et al., 1965). Plasma nonesterified fatty acids (NEFA) were determined using a modified version of the Wako NEFA C ACS-ACOD method (Wako Chemicals USA, Inc., Richmond, VA) as described by Johnson and Peters (1993). Plasma glucose was determined using the automated colorimetric procedure described by Gochman and Schmitz (1972).

Apparent digestibility of diet DM, CP, and fiber constituents were estimated from nutrient intake and fecal excretion. Hay digestibility was calculated by correcting the fecal DM output for contributions from molasses and soybean hulls. Assumed DM digestibility was 75% for molasses and 70% for soybean hulls (NRC, 1996).

Intake and digestion coefficient variables were statistically analyzed using PROC MIXED of SAS (SAS Inst., Inc., Cary, NC). The model included effects for period, diet, week, period × week, and diet × week. Animal was considered random and week was a repeated measure with animal as the subject. Blood metabolites were analyzed with diet and period in the model. Animal was treated as random.

Five sets of preplanned, nonorthogonal contrasts were constructed to isolate dietary treatments: 1) hay and soybean hulls vs hay alone; 2) hay and molasses vs hay alone; 3) urea added to hay and molasses vs hay and molasses; 4) molasses added to hay and soybean hulls vs hay and soybean hulls; and 5) urea added to molasses, hay, and soybean hulls vs molasses, hay, and soybean hulls.

**Experiment 2**

A second experiment was conducted to determine the effects of the supplements on intake and growth. The study was conducted at the University of Florida Beef Research Unit in Gainesville from October 2001 to December 2001. The University of Florida Institutional Animal Care and Use Committee approved all protocols.

Thirty-six Angus and Angus-cross calves (30 steers and 6 heifers) were sorted by weight and assigned randomly to 6 pens equipped with Calan head gates (American Calan, Inc., Northwood, NH) to determine individual intake using the same dietary treatments as in Exp. 1. The 6 heifers were assigned randomly one to each pen, and each received a different treatment diet. The steers within a pen were assigned randomly 1 of the 5 remaining treatment diets so that all diets were represented in each pen (total of 6 pens). Animals were trained to use the gates for 2 wk prior to the start of the experiment. During the training period, all animals received bahiagrass hay ad libitum supplemented with a concentrate diet composed of 67% corn, 20% soybean hulls, 2.5% commercial protein pellet, and 10.5% molasses. All animals continually had access to water, loose salt, and minerals. The experimental hay was cut a year later from the same pasture as that used in Exp. 1 and was similar in chemical composition (Table 1).

After the 2-wk training phase, the intake and growth experiment was conducted over 6 wk. Sufficient hay was offered daily so that approximately 10% was refused. Refusals were weighed back, and samples of all feedstuffs were taken weekly. Weekly samples of feeds and refusals were dried at 65°C and ground to pass through a 1-mm screen and analyzed for DM, CP, ADF, and NDF as in Exp. 1.

Weights of animals were taken initially (average of d 1 and 2), at midpoint (d 21), and at the end of the experimental phase (average of d 42 and 43). Blood samples (approximately 10 mL) were taken on d 21 and 42 by jugular venipuncture into vacuum tubes that contained EDTA and analyzed for PUN, NEFA and glucose as in Exp. 1. All blood samples and weights were taken in the morning prior to feeding hay or supplements.

Intake and blood metabolite data were statistically analyzed using the MIXED procedure of SAS. The model included pen, diet, week, and diet × week where weeks were 1 through 6 for intake and 3 and 6 for blood metabolites. Week was analyzed as a repeated measure with animal as the subject. If the diet × week effect was significant, then analyses were conducted for each week with only diet in the model. Average daily gain was analyzed with a simple model including pen and diet effects with pen as random. Contrasts were determined as in Exp. 1.

### Table 1. Chemical composition of bahiagrass hay and supplements fed to cattle in digestion experiment (mean ± SE).

<table>
<thead>
<tr>
<th>Item</th>
<th>Bahiagrass Hay</th>
<th>Molasses</th>
<th>Soybean Hulls</th>
<th>Urea</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM, %</td>
<td>Exp. 1, 90.9</td>
<td>Exp. 2, 92.5</td>
<td>71.0</td>
<td>92.2</td>
</tr>
<tr>
<td>OM, % DM</td>
<td>95.3</td>
<td>95.1</td>
<td>84.7</td>
<td>91.8</td>
</tr>
<tr>
<td>CP, % DM</td>
<td>9.4</td>
<td>8.9</td>
<td>9.6</td>
<td>11.1</td>
</tr>
<tr>
<td>NDF, % DM</td>
<td>80.1</td>
<td>84.7</td>
<td>—</td>
<td>62.7</td>
</tr>
<tr>
<td>ADF, % DM</td>
<td>44.5</td>
<td>48.0</td>
<td>—</td>
<td>46.4</td>
</tr>
</tbody>
</table>

†From NRC, 1996.
RESULTS AND DISCUSSION

Experiment 1

The hay was typical for bahiagrass produced in the subtropical zones of the United States. Crude protein concentration (Table 1) was approximately 9%, which is probably adequate for maintenance of mature cows, but not for growing animals (NRC, 1996). Both NDF and ADF were high and typical for bahiagrass hay. Crude protein of soybean hulls (11.1%) was slightly lower, and that for molasses (9.6% DM) was higher than expected. Urea was added to molasses at 3.5% weight-weight basis (as fed) to achieve an anticipated 16% supplement. However, the elevated molasses CP content resulted in the molasses-urea supplement containing about 21% CP equivalent.

Intake of hay and diet DM, and digestibility of hay, DM, and CP increased \( P < 0.10 \) over the 2 collection weeks. There were no interactions of dietary components and week, indicating any adaptation to supplement components was consistent among treatment. Therefore, specific data for weeks are not presented. Period effects were significant for digestibility coefficients with period 3 having about 4 percentage units greater digestibility than periods 1 and 2. However, intake was higher \( P < 0.01 \) in period 2.

Even though the amount of hay offered was only 90% of that consumed during the previous 30 d by each animal, some refusal was left. Previous work has shown that intake in digestion stalls is about 85% of that in free stalls (S.W. Coleman, unpublished results). Daily hay intake was lower by 0.27% BW \( P < 0.05 \) when supplemented with molasses as compared with hay fed alone, but diet DM intake increased \( P < 0.05 \) by a similar amount, indicating the added molasses substituted for about half the depression in hay intake (Table 2). When urea was added to the molasses, animals ate more hay \( P < 0.05 \) and total DM \( P < 0.01 \) than those fed hay and molasses without urea. The increased intake with urea supplementation was mostly a recovery to intake levels of hay alone, and made up for the depression caused by molasses supplementation (Table 2). Soybean hulls alone, with molasses, or with molasses-urea did not affect hay intake; therefore, DMI increased with the addition of each supplement source.

Digestibility of DM and CP for the hay alone was 57.3 and 45.4%, which represents typical mature bahiagrass, one of the staple forages, either as hay or standing forage, for wintering cows in the Gulf Coast regions of the United States. The DM digestibility would meet the requirements for dry, pregnant, mature cows in the last trimester of pregnancy (NRC, 1996) and possibly would meet the requirements of lactating cows with low to average milk production. The poor digestibility of protein is consistent with the high ADF insoluble N of bahiagrass as compared with Bermudagrass and stargrass (Johnson et al., 2001) indicating that much of the N is not available to rumen microbes.

Total diet DM, OM, and ADF digestibility were increased \( P < 0.01 \) when soybean hulls were fed as a supplement to bahiagrass hay (Table 2), consistent with results of Martin and Hibbert (1990). Although soybean hulls contain high levels of fiber, the fiber is deemed more digestible than that of the hay (NRC, 1996). Apparent digestibility of CP and NDF and estimated hay digestibility were not affected by soybean hulls. Molasses added to hay alone tended to improve \( (P < 0.10) \) DM digestibility, but caused a decrease in CP \( (P < 0.10) \), NDF \( (P < 0.01) \), and ADF \( (P < 0.01) \) digestibility; however, only NDF and ADF digestibility were significantly depressed when molasses was added to hay-soybean hulls. Addition of urea to hay and molasses increased apparent digestibility of CP \( (P < 0.01) \), NDF \( (P < 0.05) \), and ADF \( (P < 0.10) \), but had no effect on digestibility of other constituents. When soybean hulls were included in the diet, urea also increased \( P < 0.05 \) CP digestibility, but to a lesser extent.

Heldt et al. (1997) observed reduced fiber digestion in animals fed diets containing glucose, fructose, sucrose, or starch as compared with that noted in control animals when RDP was fed at a low level (0.031% BW). In contrast, at a higher level of RDP (0.122% BW), fiber digestion was improved by the addition of sugars. In another study, Heldt et al. (1999b) observed reduced fiber digestion when high levels of starch \( (0.30 \text{% BW/d}) \) were fed at low RDP (0.031% BW), but glucose had little effect. At high levels of RDP (0.122 % BW), source or level of carbohydrate supplement had little effect on fiber digestion. Ruminally degradable protein in bahiagrass hay is quite low (Johnson et al., 2001), and the addition of molasses may have exacerbated an otherwise depleted N supply for rumen microbes.

Concentrations of PUN at the end of each experimental period were higher \( P < 0.05 \) in animals fed hay supplemented with soybean hulls, but other dietary supplements had little \( P > 0.10 \) effect (Table 2). Plasma glucose concentration was not influenced \( P > 0.10 \) by dietary supplements. Plasma concentration of NEFA tended to increase \( P < 0.10 \) when urea was added to the molasses-hay diet or when molasses were added hay with soybean hulls \( P < 0.05 \), but decreased \( P < 0.05 \) when urea was added to hay-soybean hulls with molasses.

Plasma urea N is a product of absorption of ammonia released by rumen microbial activity and protein catabolism in the body, and has been used to estimate the protein to energy ratio in the diet (Hammond, 1997). A normal range for beef cattle PUN levels is 8 to 12 mg/dL, and levels below 8 mg/dL may denote inadequate dietary protein (Hammond, 1997) in relation to available energy. The only diet to support PUN concentrations above the minimum was hay supplemented with soybean hulls.
Soybean Hulls and Molasses as Hay Supplements

Table 2. Intake, nutrient digestibility, and plasma concentrations of metabolites of cattle fed bahiagrass hay supplemented with molasses or molasses-urea with or without soybean hulls (Exp. 1)

<table>
<thead>
<tr>
<th>Item</th>
<th>Dietary treatments1</th>
<th>Contrast differences2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
<td>HM</td>
</tr>
<tr>
<td>DMI, % BW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hay</td>
<td>1.74</td>
<td>1.46</td>
</tr>
<tr>
<td>Diet</td>
<td>1.74</td>
<td>2.02</td>
</tr>
<tr>
<td>Digestible DM</td>
<td>1.00</td>
<td>1.22</td>
</tr>
<tr>
<td>Digestibility, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>57.3</td>
<td>60.2</td>
</tr>
<tr>
<td>OM</td>
<td>58.7</td>
<td>60.6</td>
</tr>
<tr>
<td>CP</td>
<td>45.4</td>
<td>41.2</td>
</tr>
<tr>
<td>NDF</td>
<td>64.2</td>
<td>54.5</td>
</tr>
<tr>
<td>ADF</td>
<td>61.6</td>
<td>53.5</td>
</tr>
<tr>
<td>HayΦ</td>
<td>57.2</td>
<td>53.5</td>
</tr>
<tr>
<td>Plasma metabolites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urea, mg/dL</td>
<td>3.21</td>
<td>2.31</td>
</tr>
<tr>
<td>Glucose, mg/dL</td>
<td>70.2</td>
<td>72.8</td>
</tr>
<tr>
<td>NEFA,5 μEq/L</td>
<td>441</td>
<td>490</td>
</tr>
</tbody>
</table>

1H = hay; M = molasses; U = urea; S = soybean hulls.
2Contrasts: (1) hay and soybean hulls vs hay alone; (2) hay and molasses vs hay alone; (3) urea added to hay and molasses vs hay and molasses; (4) molasses added to hay and soybean hulls vs hay and soybean hulls; and (5) urea added to molasses, hay, and soybean hulls vs molasses, hay, and soybean hulls.
3SE = pooled standard error.
4Calculated after adjusting fecal output for contribution by molasses and soybean hulls in the appropriate diets.
5NEFA = Nonesterified fatty acids.
6Statistically significant, $P < 0.10$.
7Statistically significant, $P < 0.05$.
8Statistically significant, $P < 0.01$.

Molasses added to hay and soybean hulls had little additional effect on all measured parameters over hay and soybean hulls alone, except that intake of diet and digestible DM were increased, fiber digestibility was decreased, and NEFA were increased.

**Experiment 2**

Hay intake was 1.67% of BW across all treatments during the digestion experiment (Exp. 1) and 2.85% of BW during the intake and growth experiment (Exp. 2). Constraint in digestion stalls has been estimated to reduce intake by at least 15% to that in individual free stalls or group feeding (S. W. Coleman, unpublished data). Intake of the unsupplemented hay was quite good (2.46 ± 0.7% of BW) in Exp. 2 although not sufficient to sustain BW. On the average, hay DM intake was not influenced ($P > 0.10$) by the dietary treatments (Table 3). However, there was an interaction of diet and week (Figure 1) because during wk 4 and 6, molasses improved intake ($P < 0.05$). Whereas animals consuming molasses and urea also consumed more than animals fed hay alone during those weeks, the addition of urea was not different ($P > 0.10$) than that for molasses alone.

Average weight gains over the 56 d ranged from −0.15 to 0.30 kg/d and were influenced ($P < 0.05$) by diet (Table 3). Steers fed hay with soybean hulls gained 0.26 kg/d more ($P < 0.10$) than those fed hay alone. Even though they ate more hay, steers supplemented with molasses alone lost weight almost as much as those fed hay alone. The addition of urea to hay and molasses improved gains ($P < 0.10$) even though the increase in intake was marginal. Hay intake was not depressed in these studies, which resulted in an increase in diet and diges- tible DM, and a response of 0.26 kg/d in gain. These data corroborate that ADG can be improved by the addition of soybean hulls to a forage-based diet (Anderson et al., 1988; Garces-Yepez et al., 1987) with only minimal substitution effects that are often found with other energy-dense supplements (Chase and Hibberd, 1987; Moore et al., 1999).

Although the average hay intake during the during the digest experiment was depressed by supplementation with molasses alone (Contrast 2; see Table 3), the digestible DM intake was improved. On the other hand, hay intake was increased with molasses supplementation during the in-
Table 3. Hay intake, weight gain and plasma concentration of metabolites in cattle fed bahiagrass hay supplemented with molasses or molasses-urea with or without soybean hulls (Exp. 2).

<table>
<thead>
<tr>
<th>Item</th>
<th>Dietary treatments</th>
<th>Contrast differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
<td>HM</td>
</tr>
<tr>
<td>Hay DMI, % BW</td>
<td>2.46</td>
<td>2.17</td>
</tr>
<tr>
<td>Initial wt, kg</td>
<td>234</td>
<td>210</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>-0.15</td>
<td>-0.12</td>
</tr>
<tr>
<td>Plasma metabolites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urea, mg/dL</td>
<td>4.00</td>
<td>4.04</td>
</tr>
<tr>
<td>Glucose, mg/dL</td>
<td>73.5</td>
<td>71.2</td>
</tr>
<tr>
<td>NEFA, μEq/L</td>
<td>711</td>
<td>649</td>
</tr>
</tbody>
</table>

1H = hay; M = molasses; U = urea; S = soybean hulls.
2Contrasts: (1) hay with soybean hulls vs hay alone; (2) hay and molasses vs hay alone; (3) urea added to hay and molasses vs hay and molasses; (4) molasses added to hay and soybean hulls vs hay and soybean hulls; and (5) urea added to molasses, hay, and soybean hulls vs molasses, hay, and soybean hulls. Number represents difference in contrasts.
3SE = pooled standard error.
4NEFA = Nonesterified fatty acids.
5Statistically significant, P < 0.10.
6Statistically significant, P < 0.05.
7Statistically significant, P < 0.01.

Hay intake trial, but ADG was reduced. The conflicting trends in intake with molasses supplementation might have resulted from the relative levels of hay intake and the proportion of total DM supplied by the molasses. Delgado et al. (1978) also reported that animals supplemented with molasses had lower gains than unsupplemented animals. Petit et al. (1994) found no effect of molasses on ADG, but Petit and Veira (1994) found that molasses at 7.5 or 15% of a timothy silage diet depressed ruminal ammonia-N concentration and fiber digestibility but increased energy digestibility. We also demonstrated reduced fiber digestibility (Table 2) with molasses supplementation, which follows the theory that microbial activity changes when rapidly fermentable carbohydrates are available (Foreman and Herman, 1953; Strobel and Russell, 1986). These changes can negatively affect fiber digestion, possibly by decreasing the rumen pH and inhibiting cellulolysis (Martin et al., 1981; Chase et al., 1988; Piwonka and Firkins, 1996), but as found with the intake experiment (Table 3), depression of intake does not always occur. Hatch and Beeson (1972) replaced corn with molasses (1 kg/d) and observed higher diet DM digestibility. Although conflicting data abound in the data concerning energy supplementation and its effect.
on intake, digestibility, and ultimately performance, Moore et al. (1999) observed that intake was generally reduced when supplemental energy exceeded 0.7% of BW digestible organic matter (DOM), when forage DOM to CP ratio was less than 8, or when intake of the forage source alone exceeded 1.75% of BW. Two of the 3 scenarios existed for the intake trial (Exp. 2) in the current study. Hay OM intake fed alone was about 2.3% of BW and the DOM to CP ratio was about 6.7, assuming the hay OM digestibility in Exp. 2 was similar to that in Exp. 1. The DOM to CP ratio was also < 7 for Exp. 1, and intake of hay approached 1.75% of BW.

Past research indicates that the addition of urea to supplements can increase gain (Beams, 1959; Delgado et al., 1978). Pate et al. (1990) found that urea added to supplemental molasses made a numerical, but not statistically significant, improvement in age-based or near maintenance diets. Moreover, the addition of urea to supplements can increase PUN, possibly an indication of energy deficit and fat mobilization by the animal to provide additional energy. Yelich et al. (1995) demonstrated that NEFA concentrations increased from about 300 to 800 μEq/L over 16 wk in which weanling beef heifers were fed a maintenance diet. During the second year the heifers were thinner at weaning, and NEFA increased from 600 to 1,000 μEq/L. Well-fed animals during both years maintained NEFA levels from 300 to 400 μEq/L, slightly lower than the steers in the current study. Thus it appears that 200 μEq/L as suggested by Drackley (2000) might be unrealistic for growing animals, particularly if they are fed forage-based or near maintenance diets.

**IMPLICATIONS**

The bahiagrass hay fed alone was relatively low quality and was inadequate to meet the nutritive needs of growing cattle. Both soybean hulls and fortified molasses were effective supplement sources in forage-based systems by increasing ADG without decreasing hay intake. For molasses to be effective, it should be fortified with a N source; an inexpensive and effective source is urea. Molasses and soybean hulls complemented each other when fed together, especially with added urea.

**LITERATURE CITED**


Hatch, C. F., and W. M. Beeson. 1972. Effect of different levels of cane molasses on nitro-


