EFFECTS OF ENERGY AND PROTEIN SUPPLEMENTATION OF AMMONIATED TROPICAL GRASS HAY ON THE GROWTH AND CARCASS CHARACTERISTICS OF CULL COWS

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ABSTRACT

Laboratory, digestion and growth studies were used to evaluate energy and protein supplements for ammoniated (4% of the forage DM) stargrass (Cynodon.nlemfuensis Vanderyst var. nlemfuensis) hay. Ammoniation increased (P < .05) total N concentration (.7 to .9% vs 1.7 to 2.0%) and in vitro digestion of OM, NDF and ADF and reduced (P < .05) NDF concentration of stargrass hay. Two digestion (3 x 3 Latin square, 250-kg steers) and two growth (400-kg Brahman crossbred cull cows, eight head per pasture, two pastures per treatment, November through February) trials evaluated citrus pulp or liquid cane molasses (Trial 1) and molasses or molasses plus cottonseed meal (Trial 2) supplementation of ammoniated hay. Supplementation with byproduct energy sources, citrus pulp or molasses (either alone or with cottonseed meal), improved (P < .05) OM digestibility but reduced (P < .05) NDF and ADF digestibilities. Apparent nutrient digestibilities were similar (P > .05) between diets supplemented with citrus pulp and molasses and between diets supplemented with molasses and molasses plus cottonseed meal. In Trial 1, ADG by cull cows was greater (P < .05) for citrus pulp- (.71 kg) or molasses- (.68 kg) supplemented diets than for hay fed alone (.49 kg). In Trial 2, ADG was greater (P < .05) for cull cows fed ammoniated hay supplemented with molasses plus cottonseed meal (.85 kg) than for those supplemented with molasses only (.69 kg). Feeding cows over the winter increased their (P < .05) carcass weight, marbling score, USDA quality grade and lipid percentage of the 9-10-11 rib section compared with cows slaughtered at the beginning of the experiment. Supplementation of ammoniated hay with energy or with energy and protein improved cull cow performance and their carcass characteristics.

Key Words: Ammoniated Feeds, Associative effects, Forage, Energy, Protein, Carcass Characteristics

Introduction

Many livestock producers cull and sell a portion of their cow herd each year, usually in the fall when calves are weaned. Cull cow prices typically follow a seasonal pattern; they are lowest in the fall and higher the following spring (Florida Agricultural Statistics, 1988). In addition, a price advantage exists for cows of higher quality grade. Many cull cows are in poor condition in the fall; they may grow efficiently if given adequate nutrition. However, relative profit of winter feeding vs marketing in the fall will be influenced by the cost of gain obtained from a winter feeding program.

Treating low-quality hay with anhydrous ammonia has improved forage nutritive value and increased hay intake and daily gain by cattle (Paterson et al., 1981; Brown, 1988; Mason et al., 1989a). Ammoniated forage may provide a basal diet upon which energy and protein supplementation programs can be applied. These experiments were conducted to

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evaluate byproduct energy source (citrus pulp and liquid cane molasses) and cottonseed meal supplementation of ammoniated ‘Ona’ stargrass (Cynodon nlemfuensis Vanderyst var. nlemfuensis) hay on growth rate and carcass characteristics of cull cows.

Materials and Methods

Forage Treatment and Analysis. Mature stargrass was harvested and stored as hay (approximately 350 kg round bales, 90% DM) in two consecutive years. In each year, three stacks of 84 bales each were treated with anhydrous ammonia (4% of the forage DM) in a manner similar to that described by Brown (1990). Briefly, round bales were stacked on the ground in a pyramid configuration. With 84 bales per stack, this resulted in a base stack length of 14 units. A trench approximately 30 cm wide x 45 cm deep was dug around the stack. Black polyethylene plastic (1.5 mm thick) was placed over the stack and the edges were sealed into the trench with soil. An anhydrous ammonia tank containing a percentage capacity gauge was parked by the stack, and the end of the hose from the tank was placed under the plastic about midway down the stack. The proper quantity of anhydrous ammonia was metered under the plastic over a 2-h period using the percentage capacity gauge. Before ammoniation in each year, approximately 20 bales of untreated hay in each stack were sampled with a core sampler; samples were composited within the stack. From 45 to 60 d after ammoniation each year, approximately 20 bales of ammoniated hay in each stack were sampled; these samples also were composited within the stack. The bales in each stack sampled before and after ammoniation were not necessarily the same bales. Samples from each of the three stacks were kept separate, as were those taken before and after ammoniation.

Samples were dried in a forced-air oven at 50°C and ground through a 1-mm screen. Laboratory DM, OM and total N were determined according to AOAC (1975) procedures. Neutral detergent fiber, ADF and ADL were determined by the procedures of Goering and Van Soest (1970) and Golding et al. (1985). The proper quantity of potentially digestible NDF was regressed against time (Smith et al., 1971). No lag phase was observed for any sample.

For all nutritive value variables, a mean value for untreated and ammoniated hay in each stack was calculated. Hay stack was considered the experimental unit. Data were analyzed as a completely randomized design, with sums of squares partitioned into treatment effects. Treatment means were separated using a significant F-test (Steel and Torrie, 1980).

Digestion Trials. In each year, three bales of ammoniated hay from each of the three stacks were selected randomly, ground through a 5-cm screen and stored separately by stack under cover (three groups of three bales each). In each year, hay from a given stack was used in each period of the three-period digestion trials described below.

In both trials, six Brahman crossbred steers averaging 225 kg in Trial 1 (Year 1 hay) and 270 kg in Trial 2 (Year 2 hay) were utilized in a replicated 3 x 3 Latin square design, with the squares conducted concurrently. In digestion Trial 1, the following treatments were evaluated (DM basis): 1) 100 % ammoniated hay, 2) 80% ammoniated hay plus 20% liquid cane molasses and 3) 80% ammoniated hay plus 20% citrus pulp. The following treatments were evaluated in digestion Trial 2 (DM
November 3, 1987 and ended on March 1, 1988 (118 d). Cows in one group were slaughtered at the start of the trial for measurement of initial carcass characteristics. The remaining six groups were assigned to the following three treatments, yielding two groups per treatment: 1) ammoniated hay alone, 2) ammoniated hay plus 3.4 kg DM of liquid cane molasses per day and 3) ammoniated hay plus 2.9 kg DM of liquid cane molasses plus .5 kg DM of cottonseed meal per day. The trial began on November 19, 1988 and ended on March 9, 1989 (110 d).

In each trial, each group of cows was placed on a 1-ha 'Pensacola' bahiagrass (Paspalum notatum Flugge) pasture. Forage availability from the bahiagrass pastures was not measured, but it was minimal during the trials. Cattle remained in their respective pastures during the entire experiment and the same pastures were used in both trials. Cows had ad libitum access to ammoniated hay in round bale feeders. All hay was weighed before feeding. Hay not consumed at the end of the trial was weighed; waste was minimal. Supplements were fed in open troughs three times weekly and were completely consumed. The mineral-vitamin mix described above was fed free choice. Cows were adjusted to the diets for 4 d and then weighed on three consecutive days both at the beginning and at the end of the trials.

At the end of the trials, cows were slaughtered at a commercial packing plant following standard slaughter procedures. Approximately 24 h postmortem, each carcass was evaluated for USDA quality and yield grade characteristics. In addition, fat color was subjectively evaluated (1 = white, 4 = very yellow). A 9-10-11 section of the rib was removed according to Hankins and Howe (1946) for physical separation of lean, fat and bone. Lipid content of the separable lean and fat tissue was obtained by the ether extraction method so that fat-free lean, lipid and bone content of the 9-10-11 section could be determined. Also, a 3.8-cm section of the longissimus from the 12th rib was removed for Warner-Brazier shear (WBS) force determination. These samples were vacuum-packaged and stored at 1 ± 1°C until 5 d postmortem and subsequently frozen (−20°C) until shear force determinations could be conducted. Sections for WBS analysis were thawed for 18 h at 2 to 4°C and broiled in Farberware Open Hearth...
broilers\(^4\) to an internal temperature of 70°C (AMSA, 1978). Internal temperatures were monitored using copper-constantan thermocouples attached to a potentiometer\(^5\). Sections then were cooled at 21°C; eight cores (1.27 cm diameter) removed parallel to fiber orientation were sheared on a Warner-Bratzler shearing device.

Feed intake and ADG data from each trial were analyzed as a completely randomized design with sums of squares partitioned into treatment effects (Steel and Torrie, 1980). Means within pastures were used as the experimental unit. When a significant F-test was detected, treatment differences were determined using the following contrasts: 1) control vs supplemented and 2) citrus pulp vs molasses in Trial 1 and molasses vs molasses plus cottonseed meal in Trial 2 (SAS, 1982). Data for carcass characteristics also were analyzed as a completely randomized design with individual animal as the experimental unit (Steel and Torrie, 1980). Model sums of squares were partitioned into treatment, replicate and treatment \(\times\) replicate effects. No significant replicate or treatment \(\times\) replicate effects were noted. Therefore, replicate and treatment \(\times\) replicate effects were removed from the model. When a significant F-test was detected, treatment differences were determined using the following contrasts: 1) initial slaughter group vs all treatments at the end of the experiment, 2) control vs supplemented and 3) citrus pulp vs molasses in Trial 1 and molasses vs molasses plus cottonseed meal in Trial 2 (SAS, 1982).

### Results and Discussion

In each trial, untreated stargrass hay was low in nutritive value, as reflected by its low total N concentration, low in vitro OM and fiber digestion values and high NDF and ADF concentrations (Table 1). These untreated hays were similar in nutritive value to those received from livestock producers in the Florida extension forage testing program (Brown et al., 1989). Consistent with results using other forages (Mason et al., 1989b; Wyatt et al., 1989), ammoniation increased total N concentration and reduced NDF concentration of the stargrass hays. In vitro OM, NDF and ADF digestion values were greater for ammoniated than for untreated hays. Concentrations of ADF and ADL and rate of NDF digestion were not affected (\(P > .05\)) by ammoniation. Responses to ammoniation appeared to be greater in the stargrass hay used in Trial 1 than that used in Trial 2.

The citrus pulp used in Trial 1 was low in NDF, ADF and ADL concentration with very little hemicellulose (NDF minus ADF; Table 1). Total fiber content of citrus pulp may be greater than that represented by NDF due to the presence of viscous components of the cell wall that are soluble in neutral detergent solution. In vitro degradation of citrus pulp OM and fiber was very rapid and complete. In an evaluation of 3,630 samples, Ammerman et

### Table 1. Chemical Composition and in Vitro Digestion of Untreated and Ammoniated Star Grass\(^a\) Hay and Citrus Pulp

<table>
<thead>
<tr>
<th>Item(^b)</th>
<th>Trial 1</th>
<th></th>
<th>Trial 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Untreated</td>
<td>Ammoniated SE</td>
<td>(F^c)</td>
<td>Untreated</td>
</tr>
<tr>
<td>Total N</td>
<td>7.1</td>
<td>2.0</td>
<td>.38</td>
<td>.002</td>
</tr>
<tr>
<td>NDF</td>
<td>83.1</td>
<td>75.2</td>
<td>1.35</td>
<td>.04</td>
</tr>
<tr>
<td>ADF</td>
<td>46.0</td>
<td>45.3</td>
<td>.63</td>
<td>.07</td>
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<tr>
<td>ADL</td>
<td>6.7</td>
<td>6.0</td>
<td>.24</td>
<td>.05</td>
</tr>
<tr>
<td>IVOMD, %</td>
<td>38.8</td>
<td>54.6</td>
<td>4.69</td>
<td>.03</td>
</tr>
<tr>
<td>NDF digestion, %</td>
<td>42.1</td>
<td>61.8</td>
<td>5.90</td>
<td>.04</td>
</tr>
<tr>
<td>ADF digestion, %</td>
<td>31.8</td>
<td>56.5</td>
<td>7.16</td>
<td>.005</td>
</tr>
<tr>
<td>NDF digestion rate</td>
<td>3.8</td>
<td>4.5</td>
<td>.22</td>
<td>.09</td>
</tr>
<tr>
<td>NDF digestion extent</td>
<td>43.7</td>
<td>64.7</td>
<td>6.15</td>
<td>.01</td>
</tr>
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</table>

\(^a\)Cynodon niliense var. niliense
\(^b\)N (\% DM basis), fiber values are percentages, ash-free, OM basis, IVOMD = in vitro OM digestion, NDF digestion rate (\%h of the potentially degradable NDF), NDF digestion extent (g NDF digested in vitro at 96 h/100 g NDF).
\(^c\)Probability value.
TABLE 2. APPARENT DIGESTIBILITY BY STEERS AND GROWTH PERFORMANCE BY CULL COWS FED AMMONIATED STARGRASSa HAY ALONE AND SUPPLEMENTED WITH CITRUS PULP OR CANE MOLASSES

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>P-valueb</th>
<th>SE</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestion Trial 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OM intake, kg</td>
<td>Control</td>
<td>4.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Citrus pulp</td>
<td>4.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cane molasses</td>
<td>4.3</td>
<td>.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OM digestibility, %</td>
<td>Control</td>
<td>58.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Citrus pulp</td>
<td>61.7</td>
<td>.46</td>
<td>.03</td>
<td>.73</td>
</tr>
<tr>
<td></td>
<td>Cane molasses</td>
<td>62.0</td>
<td>.52</td>
<td>.04</td>
<td>.68</td>
</tr>
<tr>
<td>NDF digestibility, %</td>
<td>Control</td>
<td>65.9</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Citrus pulp</td>
<td>62.5</td>
<td>.55</td>
<td>.04</td>
<td>.83</td>
</tr>
<tr>
<td></td>
<td>Cane molasses</td>
<td>63.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADF digestibility, %</td>
<td>Control</td>
<td>61.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Citrus pulp</td>
<td>58.3</td>
<td>.55</td>
<td>.04</td>
<td>.83</td>
</tr>
<tr>
<td></td>
<td>Cane molasses</td>
<td>58.6</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Growth Trial 1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Daily feed, kg DM</td>
<td>Hay</td>
<td>13.4</td>
<td>.35</td>
<td>.05</td>
<td>.37</td>
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<tr>
<td></td>
<td>Citrus pulp</td>
<td>11.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cane molasses</td>
<td>12.1</td>
<td>.25</td>
<td>.93</td>
<td>.65</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>13.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily gain, kg</td>
<td>Control</td>
<td>.49</td>
<td>.041</td>
<td>.02</td>
<td>.88</td>
</tr>
<tr>
<td></td>
<td>Citrus pulp</td>
<td>.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cane molasses</td>
<td>.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

aCynodon nlemfuensis Vanderyst var. nlemfuensis.
bProbability value for the following contrasts: 1 = control vs supplemented, 2 = citrus pulp vs molasses.

al. (1976) found that total N concentration of citrus pulp was dependent on the proportion of seeds present; they reported an average value of 1.1% N, the same as we found (Table 1).

*Digestion Trials.* Supplementation of ammoniated stargrass hay with citrus pulp (Table 2) or molasses either alone or with cottonseed meal (Tables 2 and 3) increased \( P < .05 \) OM digestibility but reduced \( P < .05 \) NDF and ADF digestibilities compared with ammoniated hay fed alone. In Trial 1 (Table 2), apparent OM, NDF and ADF digestibilities were similar \( P > .10 \) between the citrus pulp- and molasses-supplemented diets. In Trial 2 (Table 3), supplementation of ammoniated stargrass hay with cottonseed meal, in addition to molasses, did not influence \( P > .10 \) apparent dietary digestibilities of OM, NDF or ADF as much as supplementation with molasses alone.

Supplementation of forage-based diets with readily available carbohydrates such as starch from grain (Chappell and Fontenot, 1968; Mould et al., 1983a; Anderson et al., 1988) or sugars from molasses (Mould et al., 1983b; Brown et al., 1987) improved dietary DM or OM digestibility in some but not all cases and reduced dietary fiber digestibility. Work of Burroughs et al. (1949) and that of Mould et al. (1983b), Brown et al. (1987) and Brown (1990) suggest that energy supplementation reduces fiber digestion to a greater degree in low- than in high-quality forages. Mould et al. (1983b) found that molasses supplementation resulted in a 46.5% reduction in in situ DM digestion (DMD) of higher-quality (46.7% DMD) hay, compared to a 66.6% reduction in lower-quality (29.2% DMD) hay. Digestibility of lower-quality forages may be limited by forage CP concentration; reduction in DMD due to energy supplementation of low-quality forages has been partially alleviated by protein supplementation (Burroughs et al., 1950; el-Shazly et al., 1961). In trials in which supplemental protein was fed, Brown et al. (1987) found that molasses-urea supplementation (25% of the diet DM) of low-quality, untreated hay (48% OM digestibility) did not improve dietary OM digestibility, whereas NDF digestibility was reduced by 11%. In the present study, molasses supplementation increased dietary OM digestibility of ammoniated hay (59% OMD) but reduced \( P < .05 \) NDF digestibility by only 5% in Trial 1 and 7% in Trial 2. These results may help to explain the differential response in apparent nutrient digestibilities as affected by energy supplementation of forage-based diets and demonstrate the importance of forage quality in developing feeding programs for cattle with higher nutrient requirements.

*Growth Trials.* In both trials, cows fed ammoniated hay alone consumed large quantities of hay (approximately 3% of BW; Tables 2 and 3). In Trial 1 (Table 2), supplementation of ammoniated hay with citrus pulp or molasses reduced \( P < .05 \) hay intake. Supplements replaced equal amounts of hay DM, resulting in similar \( P > .10 \) total DMI among the three treatments. In Trial 2 (Table
3), cows supplemented with molasses or molasses plus cottonseed meal had reduced (P < .05) hay intake compared with cows fed ammoniated hay alone. But the level of supplement intake was greater than the reduction in hay intake, resulting in an increased (P < .05) total feed intake for cows fed ammoniated hay plus supplement. Molasses supplementation reduced intake of the basal component of high-fiber (Mbatya et al., 1983) and high-grain (Heinemann and Hanks, 1977) diets. Bond and Rumsey (1973) found that hay intake by cows fed molasses at 25% of the diet DM was reduced. In that trial, molasses DM replaced equal amounts of hay DM, resulting in similar total DMI between cows fed hay alone and those fed hay plus molasses. However, in their second study, when molasses was fed at 40% of the diet DM, replacement rates were less than 1.0, resulting in greater total intake for calves fed hay plus molasses. Golding et al. (1976) found that replacement rates were less than 1.0 for grain supplementation of forage-based diets; they determined that replacement rates were greater for higher-quality forage.

In Trial 1 (Table 2), cows fed ammoniated hay plus citrus pulp or molasses had a greater (P < .05) ADG than cows fed ammoniated hay alone. Daily gain was similar (P > .10) between cows fed ammoniated hay plus citrus pulp or ammoniated hay plus molasses. Chapman et al. (1953) found no difference in ADG when steers grazing St. Augustine grass (Stenotaphrum secundum) pastures were supplemented with citrus pulp or molasses. In a later study, however, Chapman et al. (1961) found that supplementation of steers grazing St. Augustine grass pastures with citrus pulp resulted in a greater ADG than did supplementation with molasses.

In Trial 2 (Table 3), cows supplemented with molasses or molasses plus cottonseed meal had improved (P < .05) ADG compared with cows fed ammoniated hay alone. For all treatments, intake of CP from the ammoniated hay was more than adequate to meet the CP requirement of a dry, pregnant, mature cow (NRC, 1984). Increased (P < .05) ADG by cull cows supplemented with cottonseed meal above those supplemented with molasses may have been due to an increased postruminal supply of protein (Stock et al., 1981) and(or) an increased ruminal microbial protein production, although total tract OM and fiber digestibilities were not increased by cottonseed meal supplementation. Hunt et al. (1989) also found that ADG by steers increased with no increase in apparent dietary DM or NDF digestibilities by cottonseed meal supplementation of a hay with low CP content.

Carcass Characteristics. In Trial 1, cows fed ammoniated hay either alone or with citrus pulp or molasses had greater (P < .01) hot carcass weights and greater (P < .01) amounts of marbling, leading to higher (P < .01) USDA quality grades than did cows at the beginning.
of the experiment (Table 4). Dressing percentage was not affected ($P > .10$) by treatment. Feeding cows over the winter resulted in firmer ($P < .01$) lean, whiter ($P < .05$) fat color, more ($P < .01$) fat opposite the longissimus and larger ($P < .01$) longissimus areas compared with cows slaughtered at the beginning of the trial. Feeding cows over the winter resulted in increased ($P < .01$) lipid percentage, decreased ($P < .01$) bone percentage and decreased ($P < .05$) fat-free lean percentage of the 9-10-11 rib compared with cows slaughtered at the beginning of the experiment. Swingle et al. (1979) also reported that lipid was the largest component of carcass gain when cull cows were realimentated with diets ranging from 22 to 80% concentrates.

Cows fed ammoniated hay and supplemented with energy in the form of citrus pulp or molasses had greater ($P < .01$) levels of marbling, higher ($P < .01$) USDA quality grades, greater ($P < .05$) percentage of lipid and lower ($P < .06$) percentage of fat-free lean in the 9-10-11 rib component than cows fed ammoniated hay alone (Table 4). There was a trend ($P = .08$) for cows receiving additional molasses or citrus pulp to have larger longissimus muscle areas. Source of supplemental energy had no influence ($P > .10$) on carcass traits or 9-10-11 rib composition. Lean was darker ($P < .05$) from cows supplemented with citrus pulp than from cows supplemented with molasses.

In Trial 2, cows fed during the winter had greater ($P < .05$) hot carcass weights, younger ($P < .01$) lean maturity, more ($P < .01$) marbling, greater ($P < .01$) USDA quality grade, larger ($P < .01$) ribeye areas, lighter ($P < .01$) lean and decreased ($P < .05$) lipid was the largest component

### Table 4. Carcass Traits and 9-10-11 Rib Composition of Cull Cows Before and After Feeding Ammoniated Star grass Hay Alone and Supplemented With Citrus Pulp or Cane Molasses

<table>
<thead>
<tr>
<th>Trait</th>
<th>Treatment</th>
<th>Citrus pulp</th>
<th>Cane molasses</th>
<th>RMSE</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of cows</td>
<td>Initial</td>
<td>7</td>
<td>13</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Hot carcass wt, kg</td>
<td>Control</td>
<td>192.3</td>
<td>232.5</td>
<td>245.5</td>
<td>251.7</td>
</tr>
<tr>
<td>Dressing percentage</td>
<td>Citrus pulp</td>
<td>47.8</td>
<td>48.5</td>
<td>50.4</td>
<td>50.8</td>
</tr>
<tr>
<td>Skeletal maturity$^a$</td>
<td>Cane molasses</td>
<td>17</td>
<td>25</td>
<td>15</td>
<td>13</td>
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<tr>
<td>Lean maturity$^a$</td>
<td></td>
<td>66</td>
<td>67</td>
<td>69</td>
<td>64</td>
</tr>
<tr>
<td>Marbling$^a$</td>
<td></td>
<td>47</td>
<td>40</td>
<td>51</td>
<td>24</td>
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<tr>
<td>Quality grade$^f$</td>
<td></td>
<td>31</td>
<td>70</td>
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<tr>
<td>Lean color$^g$</td>
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<td>5.9</td>
<td>5.9</td>
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<td>Lean texture$^g$</td>
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<td>5.3</td>
<td>5.1</td>
<td>4.6</td>
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<td>Lean firmness$^g$</td>
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<td>3.0</td>
<td>3.1</td>
<td>2.8</td>
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<td>Fat color$^h$</td>
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<td>3.2</td>
<td>2.8</td>
<td>2.6</td>
<td>2.1</td>
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<td>Fat thickness, cm</td>
<td></td>
<td>13</td>
<td>36</td>
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<td>53</td>
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<tr>
<td>Ribeye area, cm$^2$</td>
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<td>48.1</td>
<td>59.8</td>
<td>66.4</td>
<td>65.0</td>
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<td>Estimated kidney</td>
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<td>Pelvic and heart fat, %</td>
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<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
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<td>Yield grade</td>
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<td>2.0</td>
<td>2.1</td>
<td>1.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Warner-Bratzler shear, kg</td>
<td></td>
<td>6.4</td>
<td>6.0</td>
<td>6.0</td>
<td>5.6</td>
</tr>
<tr>
<td>9-10-11 rib components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fat-free lean, %</td>
<td></td>
<td>66.2</td>
<td>63.5</td>
<td>60.7</td>
<td>58.6</td>
</tr>
<tr>
<td>Lipid, %</td>
<td></td>
<td>6.1</td>
<td>14.9</td>
<td>17.6</td>
<td>20.6</td>
</tr>
<tr>
<td>Bone, %</td>
<td></td>
<td>27.7</td>
<td>21.6</td>
<td>23.6</td>
<td>20.9</td>
</tr>
</tbody>
</table>

$^a$Cynodon nlemfuensis Vandyerst var. nlemfuensis.

$^b$Standard errors for means can be calculated as RMSE/N, where RMSE = root mean square error and N = number of cows per group.

$^c$Probability value for the following contrasts: 1 = initial vs control, citrus pulp and molasses; 2 = control vs citrus pulp and molasses; 3 = citrus pulp vs molasses.

$^d$Skeletal and lean maturity descriptions according to USDA (1987).

$^e$Pd = practically devoid; T = traces; SL = slight.

$^f$Ct = cutter; Ut = utility.

$^g$1 = light cherry red color, very fine texture, very firm; 7 = black color, extremely coarse texture, extremely soft.

$^h$1 = white: 4 = very yellow.
younger (P < .01) lean color, finer (P < .01) lean texture, firmer (P < .01) lean and lower (P < .06) WBS values than cows slaughtered at the beginning of the trial (Table 5). Feeding cows over the winter also resulted in increased (P < .01) lipid percentage and decreased (P < .01) bone percentage but similar (P > .50) fat-free lean percentage of the 9-10-11 rib compared with cows slaughtered at the beginning of the experiment.

Cows fed ammoniated hay supplemented with molasses or molasses plus cottonseed meal had greater (P < .01) hot carcass weights, younger (P < .05) skeletal maturity, slightly more (P < .10) marbling, greater (P < .01) USDA quality grades, whiter (P < .01) subcutaneous fat, more (P < .01) fat opposite the longissimus muscle and more (P < .01) estimated kidney, pelvic and heart fat than cows fed ammoniated hay alone (Table 5). Also, cows fed additional molasses or molasses plus cottonseed meal had larger (P < .05) longissimus muscle areas than cows fed ammoniated hay only. In addition, cows receiving molasses or molasses plus cottonseed meal had a greater (P < .01) lipid percentage and lower (P < .01) bone percentage in the 9-10-11 rib section, indicating that the composition of the gain in carcass weight was predominantly fat tissue and not muscle tissue. Supplementing cows with protein in the form of cottonseed meal, in addition to energy from molasses and molasses plus cottonseed meal,
istics for cows fed during the winter in both Trials 1 and 2 were similar to those reported by Wooten et al. (1979) and Matulis et al. (1987), in whose studies culled cows were fed various levels of concentrates.

Conclusions drawn from both trials suggest that feeding of culled cows produced higher USDA quality grades and improvements in lean quality without detriment to USDA yield grade characteristics. Changes in composition of the 9-10-11 rib section suggest that added carcass weight gain during the supplementation period was predominantly fat (lipid). In Trial 2, however, fat-free lean percentage of lean quality without detriment to that feeding of culled cows produced higher various levels of concentrates. 

Carare weight gain during the supplementa-


tion period was predominantly fat (lipid). In

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Conclusions drawn from both trials suggest that feeding of culled cows produced higher USDA quality grades and improvements in lean quality without detriment to USDA yield grade characteristics. Changes in composition of the 9-10-11 rib section suggest that added carcass weight gain during the supplementation period was predominantly fat (lipid). In Trial 2, however, fat-free lean percentage of the rib was not changed during the supplementation period, but cows gained from 54 to 78 kg live weight, suggesting an increase in fat-free muscle mass.

Implications

Ammoniation improved the feeding value of low-quality stargrass (Cynodon nlemfuensis) hay and formed a base for supplementation for wintering culled cows. Citrus pulp or cane molasses supplementation of ammoniated hay improved weight gain by culled cows above that obtained with ammoniated hay only. Cows supplemented with molasses plus cottonseed meal gained more weight than cows supplemented with molasses only. Economical winter feeding programs for culled cows can be developed by ammoniating low-quality hay and supplementing it with natural protein plus a byproduct energy source such as molasses or citrus pulp.

Literature Cited


ENERGY AND PROTEIN SUPPLEMENTATION OF AMMONIATED HAY


