Effect of Reconstituting Field-Dried and Early-Harvested Sorghum Grain on the Ensiling Characteristics of the Grain and on Growth Performance and Carcass Merit of Feedlot Heifers

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ABSTRACT: The objective of this study was to determine whether reconstituting field-dried and early-harvested sorghum grain affected the fermentation characteristics and feed value of the ensiled grain when fed to feedlot heifers. In Trial 1, sorghum grain was harvested at 14% moisture, rolled, and reconstituted to 25, 30, or 35% moisture, then ensiled in laboratory-scale silos. Lactic acid concentration increased (d 5 to 90) and pH decreased more rapidly (d 3 to 90) as moisture level increased (P < .05). Acetic acid concentration increased (P < .05) with moisture and day postfilling. Concentration of ethanol was highest (P < .05) in the 25 and 30% moisture grains from d 1 to 5, but by d 90 the ethanol concentration in the 25% moisture grain exceeded (P < .05) that of the two higher-moisture grains. Ammonia N concentration was lowest (P < .05) in the 25% moisture grain at all sampling times postfilling. In Trial 2, 288 heifers (BW = 286 ± 83 kg) were used to compare the feeding value of rolled, ensiled sorghum grain harvested at 25% moisture to the same grain reconstituted to 30 or 35% moisture. A steam-flaked corn (SFC) diet served as the control. Final live weight; ADG; hot carcass weight; backfat depth; marbling score; kidney, pelvic, and heart fat; and liver abscess score were not affected by grain treatment (P > .10). Dry matter intake was highest (P < .10) for heifers fed the 25 or 30% moisture sorghum grain diets and lowest for those fed the SFC diet; DMI for heifers fed the 35% moisture sorghum grain diet was intermediate. Feeding 35% moisture sorghum grain improved gain efficiency (P < .10) compared with feeding 25 or 30% moisture sorghum grain by 9.0 and 5.7%, respectively. We conclude that reconstituting sorghum grain beyond the typical moisture levels of 25 to 30% would enhance the fermentation characteristics of the ensiled grain and improve gain efficiency in feedlot heifers.

Key Words: Sorghum, Moisture Content, Silage Making, Reconstituted Products, Feedlots, Performance

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Introduction

The popularity of sorghum grain in finishing diets is proportional to its price structure relative to corn and a feedlot's ability to steam-flake, early-harvest, or reconstitute grain. Sorghum grain is usually priced at 87 to 90% the value of corn, because it is more difficult and more expensive to process and results in lower performance by finishing cattle than does corn. Hale (1984) reported that the feeding value of sorghum grain was improved by 12 to 15% when it was processed using a wet method such as steam-flaking, early-harvesting, or reconstituting. Ensiling high-moisture sorghum grain is attractive to feedlots because they have the option to feed a rapidly fermentable grain that does not require steam-flaking. To ensure a rapid ruminal fermentation and maximize starch availability, the ideal moisture range at which to ensile early-harvested sorghum grain is 25 to 30% (Perry, 1976; Hale, 1984; Hibbard et al., 1985; Stock et al., 1987). Because most sorghum grain hybrids have a narrow harvest window (i.e., a rapid dry-down), water often must be added to the grain as the harvest progresses to maintain the initial moisture content. Little is known regarding the fermentation and feeding value of high-moisture sorghum grain when the ensiling moisture content exceeds 30%.
Therefore, the objective of this study was to examine the effects of reconstituting early-harvested, high-moisture, and field-dried sorghum grain on 1) the fermentation profile during the ensiling process using laboratory-scale silos and 2) the growth performance and carcass merit of feedlot heifers compared to those being fed steam-flaked corn.

Materials and Methods

Trial 1

Harvesting and Ensiling Protocol. In the summer and fall of 1995, dryland sorghum grain (DeKalb DK-41Y, DeKalb Genetics Corporation, Lubbock, TX) grown near Manhattan, KS was harvested at approximately 86% DM and processed through a single-stage roller mill (Roskamp Champion, Waterloo, IA) with 3.1 cuts per centimeter. Particle size was not determined. The rolled grain was combined with water in a portable mixer (Davis Manufacturing Co., Bonner Springs, KS) to achieve 25, 30, or 35% moisture. Mixing time was 2 min, at which time all added water was absorbed. The three reconstituted grains were ensiled in polyvinyl chloride laboratory-scale silos (10.1 cm i.d. × 19.0 cm tall), which were packed to a similar density (approximately 300 kg of DM/m³) using a hydraulic press. Each silo was equipped with a Bunsen valve at one end that excluded air but enabled gases to escape. Silos were stored at an ambient temperature (25 to 27°C). Three silos per treatment were opened at 1, 3, 5, 10, and 90 d postfilling; the grain was mixed and subsampled, and the samples were frozen.

Laboratory Analysis. Sorghum grain samples were thawed and dried in a forced-air oven at 55°C for 48 h to determine nonvolatile DM content (AOAC, 1990). Other analyses were conducted using the freshly thawed grain samples. A 25-g aliquot of ensiled grain was combined with 250 mL of distilled, deionized water for 2 h and strained through four layers of cheesecloth. The supernatant was retained and analyzed for concentrations of ammonia N, lactic acid, VFA, and ethanol. Ammonia N was determined using a glass electrode (Orion Research, Cambridge, MD). Another 25-g sample was extracted in 200 mL of 0.2 N H₂SO₄ for 2 d and strained through four layers of cheesecloth. The supernatant was retained and analyzed for concentrations of ammonia N, lactic acid, VFA, and ethanol. Ammonia N was determined with the Conway (1957) method. Lactic acid was determined as outlined by Barker and Summerson (1941). Volatile fatty acids and ethanol were quantified with gas chromatography using Chromasorb 101 80/100 mesh. The column was 183 cm long and had a 2-mm i.d. Temperatures were 150°C for the inlet, 200°C for the oven, and 300°C for the flame ionization detector. Nitrogen was the carrier gas, with a flow rate of 40 mL/min.

Statistical Analysis. Data were analyzed using the GLM procedures of SAS (1990). Each silo served as an observation, and data were analyzed as a completely random design with a 3 × 5 factorial treatment arrangement (moisture level and day postfilling). If the interaction was significant (P < .05), differences between moisture level within day postfilling are presented. If the interaction was not significant (P > .05), statistical significance was reported for the main effects of moisture level and day postfilling (P < .05).

Trial 2

Cattle Protocol. This trial was conducted at the Southwest Research-Extension Center, Garden City, Kansas. Crossbred heifers (n = 288; BW = 286 ± 83 kg) predominantly of both Limousin and Charolais parentage were used to compare four grain treatments. The heifers were allotted to one of two weight blocks. The heavy block (BW = 307 ± 54 kg) included 144 heifers allotted randomly to 12 pens, for a total of nine heifers per pen. The light block (BW = 265 ± 63 kg) included 144 heifers allotted randomly to 12 pens, for a total of 12 heifers per pen. The heavy group was placed in open lot, earthen-floored pens with a concrete feeding apron, which provided 46 cm of linear bunk space and 15.6 m² of pen area per heifer. The light group was placed in open lot, earthen-floored pens with a concrete feeding apron, which provided 61 cm of linear bunk space and 5.6 m² of pen area per heifer. Individual treatments were assigned randomly to pens within each weight block. The heifers were implanted initially with Implus-H (Ivy Labs, Overland Park, KS) and reimplanted with Revalor®-H (Hoechst-Roussel, Somerville, NJ) on d 60 of the feeding period.

Grain Treatments and Diets. The treatments were based on four dietary sources of grain: 1) sorghum grain harvested and ensiled at 25% moisture (25); 2) reconstituted to 30% moisture and ensiled (30); 3) reconstituted to 35% moisture and ensiled (35); and 4) steam-flaked corn (SFC), which served as the control. All sorghum grain was from one dryland field, all one hybrid (yellow endosperm), and processed as described in Trial 1 (Automatic Equipment Mfg., Pender, NE). Based on visual observation, no whole berries remained after processing. The grain for Treatment 1 was packed into a concrete bunker silo immediately after processing. The grain for Treatments 2 and 3 was loaded into an auger-type feed mixer (Ensilmixer 180, Oswald Livestock Products, Garden City, KS), mixed for 2 min with the correct amount of water, and unloaded and packed into concrete bunker silos (one silo per treatment). All three bunker silos were 4 m wide, 1.8 m high, and 27.5 m long. All silos were filled to an equal extent on d 1, and filling was completed for all silos on d 2. The surface of the grain was sealed with 10-mm polyethylene, which was held in place with tires. The duration from filling to feeding was 117 d. During the feedout phase, a 14- to 16-cm length of ensiled grain was
removed each day from the exposed face. Dry matter determinations were conducted weekly for all grains. The average dry matter of the ensiled sorghum was 24.8, 30.5, and 34.5, which was similar to targeted values. The corn was flaked to 421 g/L (28 lb/bu), retention time in the steam chest was approximately 40 min, temperature above the rolls was 99°C, and the moisture content of the fresh flake was 19 to 20%.

The heifers were adapted to their final diet in 14 d using two step-up diets as described by Huck et al. (1998). The final diet (Table 1) contained 78% grain, 10% corn silage, 6% soybean meal, 3% beef tallow, and 3% supplement (DM basis). Corn silage and high-moisture sorghum grain were sampled and composited during harvest and ensiling. Corn grain used in this experiment was from a single source and it too was sampled and composited during harvest. Feedstuff composites were analyzed for CP, Ca, P, K, and Mg at a commercial laboratory before the cattle feeding experiment began. Based on these analyses the corn diet was formulated to contain 13.5% CP (17.8% of the dietary CP from urea), .7% K, .6% Ca, .4% P, and .2% Mg. The mineral supplement and soybean meal included in the SFC diet was also included in the diets containing sorghum grain. Because the corn contained 9.2% CP and the sorghum grain contained 10.4% CP, diets containing sorghum grain contained .936% more CP than the diet containing corn. The diet also contained 33 mg of monensin (Elanco Animal Health, Indianapolis, IN) and 11 mg of tylosin (Elanco Animal Health) per kilogram of dietary DM. Dry matter was measured weekly for each dietary ingredient and for the total mixed ration. Ingredient DM was used to calculate the amount of each ingredient to load batches of feed, and DM of the total mixed ration was used to calculate feed intake and gain:feed ratio.

**Response Criteria.** Beginning weight of the heifers was the average of two consecutive daily weights. Following 147-d (heavy block) and 169-d (light block) feeding periods, the heifers were processed at a commercial facility (IBP, Holcomb, KS). Final weight was determined by dividing hot carcass weight by .62, then ADG, DMI, and gain:feed ratio were calculated for each pen. At processing, hot carcass weight and the incidence and severity of liver abscesses were recorded. After the carcasses were chilled for 24 h, backfat depth was measured at the 12th rib, and USDA marbling score and kidney, pelvic, and heart (KPH) fat were recorded.

**Statistical Analysis.** For growth performance and carcass traits, the pen mean served as the experimental unit. Data were analyzed using the GLM procedures of SAS (1990) as a randomized complete block design. If the main effect of grain treatment was significant ($P < .10$), treatment means were separated using a t-test ($P < .10$).

### Results and Discussion

#### Trial 1

Overall, pH declined from 6.6 on d 1 to below 5.0 on d 90. A moisture level × day postfilling interaction

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**Table 1. Composition of diets fed in Trial 2**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Moisture, %</th>
<th>SFC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Early-harvested sorghum grain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25% Moisture</td>
<td>78.0</td>
<td>—</td>
</tr>
<tr>
<td>Reconstituted to 30% moisture</td>
<td>—</td>
<td>78.0</td>
</tr>
<tr>
<td>Reconstituted to 35% moisture</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Steam-flaked corn (SFC)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Corn silage</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Beef tallow</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Urea</td>
<td>.694</td>
<td>.694</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>.493</td>
<td>.493</td>
</tr>
<tr>
<td>Limestone</td>
<td>1.14</td>
<td>1.14</td>
</tr>
<tr>
<td>Potassium chloride</td>
<td>.166</td>
<td>.166</td>
</tr>
<tr>
<td>Salt</td>
<td>.3</td>
<td>.3</td>
</tr>
<tr>
<td>Magnesium oxide</td>
<td>.111</td>
<td>.111</td>
</tr>
<tr>
<td>Rumensin® 80 premix</td>
<td>.019</td>
<td>.019</td>
</tr>
<tr>
<td>Tylan® 40 premix</td>
<td>.012</td>
<td>.012</td>
</tr>
<tr>
<td>Vitamin A, D, and E premix</td>
<td>.02</td>
<td>.02</td>
</tr>
<tr>
<td>Mineral oil</td>
<td>.03</td>
<td>.03</td>
</tr>
<tr>
<td>Trace mineral premix</td>
<td>.015</td>
<td>.015</td>
</tr>
</tbody>
</table>

*a*Contained 176.2 g of monensin/kg of premix.  
*b*Contained 88.1 g of tylosin/kg of premix.  
*c*Supplied 4,400 IU of vitamin A, 440 IU of vitamin D, and 44 IU of vitamin E/kg of diet.  
*d*Contained (g/kg of premix): 55 Ca, 5 Co, 24 Cu, 1.6 I, 40 Fe, 160 Mn, .8 Se, and 240 Zn.
occurred for pH ($P < .01$; Figure 1) because the pH was similar across moisture levels at d 1 but decreased more rapidly ($P < .05$) with increased moisture from d 3 to 90 of fermentation. A moisture level × day postfilling interaction also occurred for lactic acid concentration ($P < .01$; Figure 2). Lactic acid concentrations were similar across moisture levels on d 1 and 3, but concentrations increased more rapidly as moisture level increased ($P < .05$) from d 5 through 90. Overall, lactic acid concentration in the reconstituted sorghum grain varied from .4 to 1.5% of the DM at 90 d postfilling. These lactic acid concentrations are similar to those previously reported in high-moisture corn (Birkelo and Sorenson, 1991; Phillip and Fellner, 1992; Wardynski et al., 1993). The relationship of moisture level to lactic acid production and pH is consistent with the results of Birkelo and Sorenson (1991). Early-harvested corn containing 27% moisture had a pH of 4.5 after 56 d of fermentation, whereas that with 22% moisture had a pH of 5.5.

The concentration of acetic acid increased with day postfilling ($P < .01$, Figure 3) beginning after d 3 for 35, d 5 for 30, and d 10 for 25% moisture sorghum grain. Averaged across time, acetic acid concentration was greater in 35 than in 25% ($P < .05$) and was intermediate in 30% moisture sorghum grain. The lactic acid concentration was similar across treatments ($P > .05$, Figure 4) and also increased with day postfilling ($P < .01$). The lactic acid concentration is a measure of the efficiency of the fermentation phase; a higher ratio indicates that a homolactic fermentation was more dominant. The numerically lower ratio for 25 than for 35% moisture sorghum grain (3.5 vs 6.1) suggests that heterolactic fermentation dominated to a greater extent in the 25% grain.

A moisture level × day postfilling interaction occurred ($P < .01$; Figure 5) for ethanol concentrations. On d 3 and 5, the 35 and 30% moisture sorghum grain had higher ethanol concentrations ($P < .05$), whereas on d 90 the highest ethanol concentration occurred in the 25% grain ($P < .05$). Greater concentrations of ethanol are considered undesirable because of its potent buffering effect. A moisture level × day postfilling interaction occurred for ammonia N concentrations ($P < .01$; Figure 6). Ammonia N concentration was similar across treatments at d 1 but was greater ($P < .05$) in both the 30 and 35% moisture sorghum grain than in 25% grain from d 3 through 90. As a percentage of total N, ammonia N...
accounted for less than 1%. Ammonia N expressed as a percentage of the total N has ranged from 6% in high-moisture ear corn (Phillip and Fellner, 1992) to between 10 and 12% in whole-plant corn silage (Bergen et al., 1974; Rust et al., 1989).

The 25% moisture sorghum grain had the least desirable fermentation based on the lowest concentration of lactic acid, numerically smallest lactic acid: acetic acid ratio, and greatest concentration of ethanol. These factors were likely responsible for 25% grain having the highest pH at 90-d postfilling. On the other hand, the 35% moisture sorghum grain fermented more rapidly and to a greater extent than either the 30 or 25% grain. This is considered desirable, because increased lactic acid production combined with less time to reach a terminal pH indicates a quicker fermentation phase, and minimizes nutrient losses in the ensiling process (Rust et al., 1989).

Trial 2

Feedlot Performance. Because the heavy block of heifers contained four replications per treatment and the light block contained three replications per treatment, data were analyzed initially with block × treatment interaction. This term was not significant (P > .10) for any response variable and was deleted from the model. The heifers were fed for an average of 158 d (Table 2). Dry matter intake was higher (P < .10) for heifers fed the 25 and 30% moisture diets than for those fed the SFC diet; DMI of heifers fed the 35% moisture diet was intermediate. Stock et al. (1987) reported that DMI was higher for steers fed reconstituted sorghum grain containing 24% moisture than for steers fed reconstituted sorghum grain containing 31% moisture. Heifers fed the 35% moisture sorghum grain and SFC diets gained faster (P < .10) than those fed the 25% moisture diet, and ADG of heifers fed the 30% moisture diet was intermediate. Gain efficiency was higher (P < .10) for heifers fed the 35% moisture and SFC diets than for those fed the 25 or 30% moisture diets. Results of several trials have shown a positive relationship between gain efficiency and moisture content of sorghum grain (Ware et al., 1977; Stock et al., 1987) and corn (Beeson and Perry, 1958). We are aware of only one trial in which ensiled grain with a moisture content near 35% was used. Stock et al. (1991) reported that steers fed high-moisture corn (HMC)
containing 36% moisture consumed 14% less DM, gained 7% slower, but were 8% more efficient than those fed HMC containing 28% moisture.

**Carcass Merit.** The average hot carcass weight was 307 kg and did not differ statistically among grain treatments (P > .10, Table 3). However, hot carcass weight was numerically greater for heifers fed the 35% moisture sorghum grain and SFC diets. Carcass backfat depth was higher (P < .10) in heifers fed the SFC diet than in those fed the 25 or 35% moisture grain diets. Marbling and liver abscess scores and KPH fat were not affected by grain treatment (P > .10).

Because final weight was calculated using a constant dressing percentage, final weights may have been biased for cattle fed SFC because they had the greatest amount of carcass backfat. However, backfat was similar for cattle fed diets containing reconstituted grain sorghum. Therefore, the final weight calculations for cattle fed reconstituted grain sorghum should not contain any bias due to differences in dressing percentage.

**General.** In a previous study, Huck et al. (1998) reported that the net energy value of steam-flaked sorghum grain (SFSG) was 86 to 97% of the value of SFC. Zinn (1991) reported that SFSG had only 92% of the net energy value of SFC for finishing steers; however, Brandt et al. (1992) reported that the net energy value of SFSG was similar to that of SFC. Data from the present study show that the net energy value of the highest-moisture sorghum grain (35%) was 96% of the value of SFC.

We calculated the NE\textsubscript{g} values for the grains fed in this study (Owens et al., 1984). The calculated NE\textsubscript{g} for 25, 30, 35, and SFC were 1.50, 1.54, 1.60, and 1.68 Mcal/kg, respectively. This compares to published values of 1.35 for dry-rolled sorghum grain, 1.50 for dry-rolled corn, and 1.62 for steam-flaked corn (NRC, 1996). Because the value for SFC in our study is similar to NRC values, it is evident that reconstituting early-harvested sorghum increases its feeding value.

Of the feed grains commonly fed in the feedlots in the high plains area (corn, sorghum grain, wheat, and barley), the starch in sorghum grain is the least

### Table 2. Effect of moisture content of sorghum grain at the time of ensiling on feedlot performance of the heifers in Trial 2

<table>
<thead>
<tr>
<th>Item</th>
<th>Moisture, %</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>SFC</th>
<th>SE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial wt, kg</td>
<td></td>
<td>287</td>
<td>286</td>
<td>286</td>
<td>287</td>
<td>.83</td>
<td>.28</td>
</tr>
<tr>
<td>Final wt, kg</td>
<td></td>
<td>489</td>
<td>494</td>
<td>496</td>
<td>501</td>
<td>3.45</td>
<td>.13</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td></td>
<td>8.3\textsuperscript{d}</td>
<td>8.3\textsuperscript{d}</td>
<td>8.0\textsuperscript{de}</td>
<td>7.7\textsuperscript{e}</td>
<td>.12</td>
<td>.01</td>
</tr>
<tr>
<td>ADG, kg/d</td>
<td></td>
<td>1.28\textsuperscript{d}</td>
<td>1.32\textsuperscript{de}</td>
<td>1.34\textsuperscript{e}</td>
<td>1.36\textsuperscript{e}</td>
<td>.02</td>
<td>.09</td>
</tr>
<tr>
<td>Gain/feed</td>
<td></td>
<td>.154\textsuperscript{d}</td>
<td>.159\textsuperscript{d}</td>
<td>.168\textsuperscript{e}</td>
<td>.175\textsuperscript{e}</td>
<td>.003</td>
<td>.01</td>
</tr>
<tr>
<td>NE\textsubscript{g}, Mcal/kg</td>
<td></td>
<td>1.50</td>
<td>1.54</td>
<td>1.60</td>
<td>1.68</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Moisture content of the early-harvested and ensiled or early-harvested, reconstituted, and ensiled sorghum grain.

\textsuperscript{b}SFC = steam-flaked corn.

\textsuperscript{c}Probability that treatment means are similar.

\textsuperscript{d,e}Means within a row with unlike superscripts differ (P < .10).

### Table 3. Effect of moisture content of sorghum grain at the time of ensiling on carcass traits of the feedlot heifers in Trial 2

<table>
<thead>
<tr>
<th>Item</th>
<th>Moisture, %</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>SFC</th>
<th>SE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot carcass wt, kg</td>
<td></td>
<td>303</td>
<td>306</td>
<td>308</td>
<td>311</td>
<td>2.1</td>
<td>.13</td>
</tr>
<tr>
<td>Backfat depth, cm</td>
<td></td>
<td>.66\textsuperscript{d}</td>
<td>.72\textsuperscript{de}</td>
<td>.66\textsuperscript{d}</td>
<td>.78\textsuperscript{e}</td>
<td>.04</td>
<td>.10</td>
</tr>
<tr>
<td>Marbling score \textsuperscript{d}</td>
<td></td>
<td>264</td>
<td>255</td>
<td>263</td>
<td>284</td>
<td>10.5</td>
<td>.29</td>
</tr>
<tr>
<td>Kidney, pelvic, and heart fat, %</td>
<td></td>
<td>2.02</td>
<td>1.90</td>
<td>1.98</td>
<td>2.04</td>
<td>.05</td>
<td>.22</td>
</tr>
<tr>
<td>Liver abscess score \textsuperscript{d}</td>
<td></td>
<td>0</td>
<td>1.90</td>
<td>.03</td>
<td>0</td>
<td>.02</td>
<td>.42</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Moisture content of the early-harvested and ensiled or early-harvested, reconstituted, and ensiled sorghum grain.

\textsuperscript{b}SFC = Steam-flaked corn.

\textsuperscript{c}Probability that treatment means are similar.

\textsuperscript{d,e}Means within a row with unlike superscripts differ (P < .10).

\textsuperscript{f}100–190 = Traces, 200–299 = slight, and 300–399 = small.

\textsuperscript{g}0 = No liver abscess and 1 = one small abscess.
available to enzymatic hydrolysis. This is because of the type and distribution of protein surrounding the starch in the endosperm (Rooney and Pflugfelder, 1986), which must be disrupted if the maximum net energy value of sorghum grain is to be realized. Stock et al. (1991) reported that increasing the moisture content of HMC from 30 to 38% increased its protein solubility from 44 to 60% of the total N. The soluble N content of the dry corn was only 14% of the total N. The positive relationship among moisture level, soluble N, and IVDMD has been well documented (Prigge, 1976; Thornton, 1976). An increase in starch availability is likely caused by an increase in protein solubility, which is a result of the disruption of the protein matrix surrounding the starch molecule (McNeill et al., 1975) and of the endosperm (Sullins et al., 1971).

The positive relationship between the moisture content of reconstituted sorghum grain and its net energy value in finishing cattle diets was documented by Ware et al. (1977) and Stock et al. (1987). Hibberd et al. (1985) and Hill et al. (1991) have shown that increased moisture content of the grain increases ruminal starch degradation, probably by solubilization of the protein matrix, making the starch granule more susceptible to enzymatic hydrolysis. The literature available indicates that the upper level of moisture evaluated previously is 28 to 30%. Results of the present study showed that increasing the moisture content from 30 to 35% in high-moisture sorghum grain was beneficial in two ways. It increased the rate and extent of lactic acid production during the ensiling process, which decreased the fermentation time required to reach a terminal pH in the ensiled grain (Bolsen et al., 1996). The improved fermentation increased the efficiency of nutrient preservation (Rust et al., 1989), which also increased the gain efficiency of the heifers by about 6% in the feedlot trial.

**Implications**

For finishing cattle, ensiled sorghum grain offers several advantages over steam-flaked sorghum, including lower processing costs and net energy values that are nearly equal to those of steam-flaked corn. Additionally, an annual supply of grain can be inventoried at harvest time. Moisture level of ensiled sorghum grain has a significant effect on its net energy value. Early-harvested grain should be reconstituted to at least 35% moisture for maximum performance of finishing cattle.

**Literature Cited**


