SUGAR CANE PRODUCTS AS POTENTIAL ENERGY SUPPLEMENTS FOR CATTLE FED LOW QUALITY ROUGHAGE

A.C. SCHLINK* and J.A. LINDSAY

SUMMARY

Five zebu crossbred heifers fitted with permanent rumen cannulae were used in two experiments to evaluate molasses and raw sugar as energy supplements for cattle fed Rhodes grass (Chloris gayana). In the first experiment the heifers were fed Rhodes grass supplemented with: (1) 1 kg molasses; (2) 1 kg molasses and 95 g urea; (3) 1 kg molasses, 65 g urea and 200 g formaldehyde treated cotton seed meal; (4) 400 g raw sugar, 90 g urea, 13 g (NH₄)₂SO₄ and 5 g mineral mix; (5) 400 g raw sugar, 60 g urea, 13 g (NH₄)₂SO₄, 5 g mineral mix and 200 g formaldehyde treated cotton seed meal. Cattle supplemented with molasses and raw sugar had similar roughage intakes, rates of dry matter disappearance and potential degradability of Rhodes grass as measured by the nylon bag technique, mean retention time of CrEDTA and fluid flow, whereas rumen volume was significantly lower in cattle receiving raw sugar. The addition of a nitrogen source to molasses improved the rate of DM loss from nylon bags and decreased butyric acid production. In the second experiment, problems associated with the poor acceptability of raw sugar were overcome by addition of 20% molasses.

Key words: cattle, molasses, raw sugar, intake, rumen function

INTRODUCTION

Molasses is widely used as an energy source for cattle grazing low quality pastures in the dry tropics. It may be used to supplement dry standing pasture or as a substitute for pasture which is depleted by heavy grazing or by fire (Wythes and Ernst 1984).

Sugar cane and sugar cane by-products have been used widely in tropical countries as ruminant feeds and research has aimed to improve their utilization by adding non-protein nitrogen, protected protein and slowly degraded carbohydrates (Preston et al. 1976; Wythes and Ernst 1984). Some information on the value of feeding sugar cane for drought affected cattle in north Queensland is available (Siebert et al. 1976). However, there is little published work on the feeding of raw sugar (sucrose) as an alternative energy source to molasses for cattle consuming low quality native pasture (Lora et al. 1972).

Molasses contains up to 46% sucrose in addition to nutritionally valuable minerals and non-protein nitrogen and is the cheapest source of supplementary energy for cattle within about 150 km of the coast in Queensland. However, the 20-30% water in molasses adds appreciably to transport costs and is inconvenient to store, compared to sugar. Sugar, however, lacks minerals and nitrogen. The objective of the present study was to compare the effect on various aspects of rumen function of raw sugar and molasses fed as separate supplements to cattle receiving ad libitum amounts of low quality roughages.

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MATERIALS AND METHODS

Five ovariectomized zebu cross bred heifers fitted with permanent rumen cannulae, weighing 213 ± 21 kg at the start of the trial, were fed ad libitum on hammer-milled Rhodes grass (Chloris gayana) hay (4 g N/kg DM) in individual covered stalls with concrete floors.

In the first experiment, the five heifers were fed the following supplements during five periods, each of 29 days using a latin-square design. The five supplements evaluated were (1) 1 kg molasses; (2) 1 kg molasses and 95 g urea; (3) 1 kg molasses, 65 g urea and 200 g formaldehyde treated cotton seed meal; (4) 400 g raw sugar, 90 g urea, 13 g (NH₄)₂SO₄, and 5 g Pfizer Ruminant Premix; and (5) 400 g raw sugar, 60 g urea, 13 g (NH₄)₂SO₄, 200 g formaldehyde treated cotton seed meal and 5 g Pfizer Ruminant Premix. All supplements were fed separately and when the raw sugar based supplement was found to be poorly accepted it was administered daily via the rumen cannula. The Rhodes grass ration was fed daily at 20% excess of the previous day's intake with residues being removed daily. After a 14 day introductory period, nylon bags measuring 230 × 90 mm (Nytrel screen of mean pore size 43 μm) were used to determine the effect of the different supplements on the potential degradability and rate of disappearance of Rhodes grass. The bags contained approximately 4 g of Rhodes grass ground through a 2 mm screen and were withdrawn after 6, 12, 18, 24, 48, 72, 96 and 120 h incubation in the rumen. The bags were thoroughly washed, oven dried at 60°C and DM loss determined. The relationship between DM disappearance (p) (g/100g DM) and time (t) in hours was described by fitting the equation:

\[ p = a + b (1 + e^{-ct}) \]

by interactive least squares procedures to derive values for a, b and c. Potential degradability was estimated as \((a + b)\).

Feed intake was determined for the following seven day period. The outflow rate of fluid was then determined by reference to the water soluble marker CrEDTA. A rumen sample was taken prior to the administration of 1 g Cr as CrEDTA, then at 2 hourly intervals for 12 h and finally at 24 h after dosing. The rumen samples were measured for pH, and subsampled for determination of the concentrations of ammonia, volatile fatty acids (VFA) and chromium. Ammonia was estimated by distillation (McSweeney & Wesley-Smith 1986), VFA by gas chromatography (Morrison et al. 1986) and chromium by atomic absorption spectrophotometry. Rumen liquid volume, mean retention time and liquid flow rate were calculated from the dilution rate of CrEDTA in rumen liquid.

In the second experiment, the same animals were used in a stepwise experiment to evaluate some additives to overcome problems of the poor intake of raw sugar based supplement. The supplements tested were (1) 1 kg molasses; (2) 400 g raw sugar; (3) 360 g raw sugar and 100 g molasses; (4) 386 g raw sugar and 16 g NaCl; (5) 346 g raw sugar, 16 g NaCl and 100 g molasses, and (6) 346 g raw sugar, 16 g NaCl, 100 g molasses and 200 g formaldehyde treated cotton seed meal. The supplement was offered to all five heifers for seven days before progressing to the next supplement. The degree of acceptance was recorded as the percentage of supplement consumed for the seven day period.

Data from the two experiments was analysed by analysis of variance. In experiment one, there were no significant period, animal or period x animal effects.

RESULTS

The form of supplementation (Table 1) did not significantly \((p > .05)\) affect intake of Rhodes grass, potential DM degradability, mean retention time of CrEDTA...
in the rumen, fluid flow rate from the rumen, rumen pH, total VFA or the proportions of acetate and propionate in the VFA. Diet composition caused significant variations in the rate of DM disappearance, volume of water in the rumen, levels of rumen ammonia and proportions of butyrate in the rumen VFA.

Addition of non-protein nitrogen with and without formaldehyde treated protein to sucrose based supplements altered rumen fermentation by reducing the production of butyric acid. The nitrogen addition also significantly increased the rate of DM disappearance from nylon bags of 2.16% DM/h for the molasses only treatment to an average of 3.90% DM/h for the nitrogen supplemented groups (Table 1).

Table 1. Feed intake, nylon bag data, fluid flow and concentrations of rumen metabolites 4 h after feeding in cattle fed molasses or raw sugar as energy sources (Expt. 1)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhodes grass intake (kg DM/d)</td>
<td>3.24</td>
<td>3.25</td>
<td>3.19</td>
<td>2.93</td>
<td>3.08</td>
<td>0.25</td>
</tr>
<tr>
<td>Nylon bag</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pot. degradability DM (%)</td>
<td>53.2</td>
<td>47.8</td>
<td>48.9</td>
<td>48.6</td>
<td>49.3</td>
<td>1.70</td>
</tr>
<tr>
<td>Rate of DM disappearance (%/h)</td>
<td>2.16a</td>
<td>3.94b</td>
<td>4.16b</td>
<td>3.86b</td>
<td>3.62b</td>
<td>0.33</td>
</tr>
<tr>
<td>Rumen volume (L)</td>
<td>46a</td>
<td>38ab</td>
<td>47a</td>
<td>34b</td>
<td>32b</td>
<td>3.2</td>
</tr>
<tr>
<td>Mean retention time of Cr EDTA (h)</td>
<td>24</td>
<td>17</td>
<td>17</td>
<td>15</td>
<td>16</td>
<td>2.4</td>
</tr>
<tr>
<td>Fluid flow (L/h)</td>
<td>2.2</td>
<td>2.3</td>
<td>2.8</td>
<td>2.3</td>
<td>2.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Rumen fluid conc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia mg N/L</td>
<td>45a</td>
<td>159ab</td>
<td>170ab</td>
<td>518c</td>
<td>291b</td>
<td>45</td>
</tr>
<tr>
<td>Total VFA m M</td>
<td>66.8</td>
<td>56.5</td>
<td>64.1</td>
<td>65.9</td>
<td>51.8</td>
<td>10.7</td>
</tr>
<tr>
<td>Composition of VFA (molar %)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetate</td>
<td>68.1</td>
<td>71.8</td>
<td>69.8</td>
<td>69.6</td>
<td>70.0</td>
<td>3.2</td>
</tr>
<tr>
<td>Propionate</td>
<td>18.7</td>
<td>20.0</td>
<td>17.4</td>
<td>20.8</td>
<td>19.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Butyrate</td>
<td>13.0a</td>
<td>7.9b</td>
<td>8.3b</td>
<td>9.6b</td>
<td>9.2b</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Figures within rows with different superscripts differ significantly (P<0.05)

In experiment 2, molasses was readily accepted whereas raw sugar was not acceptable to the heifers (Table 2). The intake of sugar was significantly (P < 0.05) improved by the addition of salt or molasses. Combination of other additives with molasses did not significantly improve acceptance of the raw sugar-molasses based supplements.

Table 2. Percentage of supplement offered consumed by cattle (Expt. 2)

<table>
<thead>
<tr>
<th>Supplement intakes (%) total</th>
<th>100a</th>
<th>10b</th>
<th>80ac</th>
<th>65c</th>
<th>87ac</th>
<th>89ac</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplement intake (× total)</td>
<td>100a</td>
<td>10b</td>
<td>80ac</td>
<td>65c</td>
<td>87ac</td>
<td>89ac</td>
<td>11</td>
</tr>
</tbody>
</table>

Figures with different superscripts differ significantly (P<0.05)

DISCUSSION

Nitrogen supplemented groups all had rumen ammonia levels in excess of the optimum levels for maximum fermentation described by Boniface et al. (1986) regardless of energy source at the time of sampling. There were significant differences between the two energy supplements in rumen ammonia levels 4 h after
feeding, but this may be attributed to the different methods of supplementation used in the experiment. Groups voluntarily consumed the molasses supplement within 2 h, whereas the sugar based supplement had to be administered via the rumen cannulae to ensure satisfactory intakes. The difference in administration (Romero et al. 1976) or the range of minerals and sugars in molasses may have influenced the efficiency of utilization of available ammonia by the rumen microbial population and resulted in lower rumen ammonia levels, as well as possibly contributing to other differences in rumen function. The addition of a nitrogen source to sucrose-based supplements significantly increased the rate of DM disappearance from nylon bags, but did not alter roughage intake, in contrast to increases of intake observed with urea infusion (Boniface et al. 1986), or with the inclusion of urea in a molasses supplement (Ernst et al. 1975).

Raw sugar supplementation significantly reduced rumen volume but did not alter mean retention time of water of the soluble marker, fluid outflow or feed intake. Molasses can contain up to 23% reducing sugars in addition to many minerals (Wythes et al. 1978) that are not present in raw sugar.

Nitrogen supplementation resulted in lower butyric acid concentration in all treatments irrespective of sugar source. Diets containing soluble sugar are characterized by a high butyrate and lower propionate fermentation pattern (Karalazos and Swan 1976). The source of soluble sugar did not significantly alter the molar proportion of propionate or acetate in the rumen.

Although raw sugar may be used to replace molasses as an energy supplement for cattle, there were problems with the acceptance of a dry sugar supplement. The addition of molasses improved the acceptability of raw sugar and further additives to molasses only made minor improvements. There is a need for further studies into the development of a suitable energy supplement based on raw sugar or, alternatively, for the sugar mills to produce molasses of higher sucrose content for cattle feed.

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REFERENCES


