Whole crop barley silage characteristics treated with sugar beet molasses or dried sugar beet pulp

Vatandoost*, M., M. Danesh Mesgaran & A.R. Vakili

Department of Animal Science, Excellence Centre for Animal Science, Faculty of Agriculture, Ferdowsi University of Mashhad, P O Box 91775-1163, Mashhad, Iran

Abstract

Whole crop barley was harvested (32.5% DM), chopped and ensiled for 30 days in laboratory silos (n= 4) as untreated (UT) or treated with SM (50 g/kg of DM) or BP (50, 75 and 100 g/kg; BP5, BP7.5 and BP10, respectively) or a mixture of SM and BP (50:50 or 50:100 g/kg sugar beet molasses: dried sugar beet pulp; MB5 and MB10, respectively). The pH of the aqueous silage extract was recorded, then, NH₃-N concentration was determined in acidified silage extract (5 ml of the extract + 5 ml of 0.2 N HCl) using a distillation method. The ruminal degradable parameters of DM of the silages were determined using an in situ procedure. Four sheep (44±3 kg live weight) fitted with rumen fistulae were used. Bags (10 × 12 cm) were made of polyester nylon cloth with a pore size of 52 µm. About 5 g DM of each sample was placed in each bag, and four bags per each sample were incubated for each time (0.0, 2, 4, 8, 16, 24, 48, 72, 96 h). For zero time, bags were washed using cold tap water. After each incubation, bags were washed in cold running water and dried in oven (60 °C, 48 h), then weighted to determine DM disappearance. The equation of P= a+b (1-e⁻⁸) was applied to determine the coefficients (a= quickly degradable fraction, b= slowly degradable fraction, c= fractional degradation rate constant). Silages treated with SM as alone or combined with BP had a significant (P<0.05) lower pH (UT= 4.07, M5= 3.70, MB5= 3.71) compared with those of the un-supplemented. The supplementation caused an increase in rapidly degradable fraction and a decrease in slowly degradable fraction of silages.

Keywords: whole crop barley silage, molasses, beet pulp, in situ degradability

*Corresponding author: Vatandoost, M.
E-mail address: vatandoost_58@yahoo.com
Whole crop barley silage characteristics treated with sugar beet molasses or dried sugar beet pulp

Vatandoost, M., M. Danesh Mesgaran & A. R. Vakili

Dept. Animal Science, Excellence Centre for Animal Science, Faculty of Agriculture, Ferdowsi University of Mashhad, P O Box 91775-1163, Mashhad, Iran

Summary

Whole crop barley was harvested (32.5% DM), chopped and ensiled for 30 days in laboratory silos (n= 4) as untreated (UT) or treated with SM (50 g/kg of DM) or BP (50, 75 and 100 g/kg; BP5, BP7.5 and BP10, respectively) or a mixture of SM and BP (50:50 or 50:100 g/kg sugar beet molasses: dried sugar beet pulp; MB5 and MB10, respectively). The pH of the aqueous silage extract was recorded, then, NH$_3$-N concentration was determined in acidified silage extract (5 ml of the extract + 5 ml of 0.2 N HCl) using a distillation method. The ruminal degradable parameters of DM of the silages were determined using an in situ procedure. Four sheep (44±3 kg live weight) fitted with rumen fistulae were used. Bags (10 × 12 cm) were made of polyester nylon cloth with a pore size of 52 µm. About 5 g DM of each sample was placed in each bag, and four bags per each sample were incubated for each time (0.0, 2, 4, 8, 16, 24, 48, 72, 96 h). For zero time, bags were washed using cold tap water. After each incubation, bags were washed in cold running water and dried in oven (60 °C, 48 h), then weighted to determine DM disappearance. The equation of $P = a + b \cdot (1 - e^{-ct})$ was applied to determine the coefficients ($a =$ quickly degradable fraction, $b =$ slowly degradable fraction, $c =$ fractional degradation rate constant). Silages treated with SM as alone or combined with BP had a significant ($P< 0.05$) lower pH (UT= 4.07, M5= 3.70, MB5= 3.71) compared with those of the un-supplemented. The supplementation caused an increase in rapidly degradable fraction and a decrease in slowly degradable fraction of silages.

Keywords: whole crop barley silage, molasses, beet pulp, in situ degradability.

Introduction

Use appropriate additives at ensiling of forage can increase nutritional value that has a positive effect on silage quality (Weinberg et al., 2002). Molasses provide a relatively cheap source of readily fermentable carbohydrate for lactic acid bacteria of fresh forage. Molasses in numerous silage experiments has been proven to be an effective silage additive in terms of promoting lactic fermentation, increasing lactic acid, reducing silage pH and generally decreasing organic matter losses (McDonald et al., 1991; Snyman & Joubert, 1996). Inclusion of dried sugar beet pulp with grass at harvesting has been shown to improve the fermentation characteristics and nutritive value of the silage (O’Kiely, 1992; Yang et al., 2004). The objective of this experiment was to quantify the whole crop barley silage characteristics treated with sugar beet molasses or dried sugar beet pulp.

Materials and Methods

Ensiling Procedures

Whole crop barley was harvested (32.5% DM), chopped and ensiled for 30 days in laboratory silos (n= 4) as untreated (UT) or treated with M5 (50 g/kg of DM) which contained extra water to reduce viscosity, or BP (50, 75 and 100 g/kg; BP5, BP7.5 and BP10, respectively) or a mixture of SM and BP (50:50 or 50:100 g/kg sugar beet molasses: dried sugar beet pulp respectively; MB5 and MB10, respectively).
Chemical Analysis

Standard procedures were used to determine the chemical composition of the samples. Crude protein (CP) was determined according to the Kjeldahl procedure (AOAC, 2004) on the Tecator Auto-analyzer (1030). Determination of neutral detergent fiber (NDF) was made using the method of Van Soest et al. (1991). The pH of the aqueous silage extract was determined using a pH meter (Metrohm 691, Swiss). Five ml of the silage extract was mixed with 5 ml of 0.2 N HCl. Ammonia-N degradation of the acidified silage extract was determined using distillation method (Kjeltec 2300 Autoanalyzer, FossTecator AB, Sweden).

In situ Technique

The ruminal degradable parameters of DM of the silages were determined using in situ procedure (Fathi Nasri et al., 2006). Four sheep (44±3 Kg, body weight) fitted with rumen fistulae were used in the present study. The bags (10x12 cm) were made of polyester nylon cloth with a pore size of 48 µm. Approximately, 5 g DM of each sample was placed in each bag, and four bags for each treatment were incubated for each time (2, 4, 8, 16, 24, 48, 72, 96 h). After removal the bags from the rumen, they were washed in cold running water and dried in an air-forced oven (60 °C, 48 h). Zero time disappearance was obtained by washing rumen-unincubated bags in a similar way.

Calculating and Statistical Analysis

The equation of $P= a+b \cdot (1 - e^{-ct})$ was applied to determine the coefficients of a= quickly degradable, b= slowly degradable and c= constant rate of degradation of the incubated samples at t= time. Effective degradability (ED) of DM, CP and NDF was then calculated according to the equation of Ørskov & McDonald (1979), where $ED= a+((b\times c)/(k+c))$ where k is the rumen outflow rate assumed to be 2, 4 or 6% h$^{-1}$ and a, b and c are as described before. Data of silage chemical components (PH, NDF, NH$_3$-N and CP) were statistically analyzed using complete randomized design. The Duncan procedure was used to test the mean significant difference at $P<0.05$. Data were analyzed using the GLM procedure of SAS.

Results and Discussion

Chemical Composition

Chemical composition of the untreated and treated WCBS are shown in Table 1. Results indicated that silages treated with molasses or molasses and sugar beet pulp effectively lowered pH ($P<0.05$). It was reported that for the best silage the pH value ranged about 3.5-4.2 (Meeske et al., 2000). In this experiment the pH values for silages found range between 3.70 and 4.24. This is predictable because of that molasses contains a high level of soluble carbohydrates and provide a source of fermentable carbohydrate for lactic acid bacteria. This finding support previous study who reported the addition of molasses in silages decreased pH (Baytok et al., 2005; McDonald et al., 1991) by simultaneously increasing lactic acid production via lactic acid bacteria (Yang et al., 2004). In this experiment NDF content of silages lowered when molasses was applied. These data showed that molasses is a stimulant of silage fermentation and caused to increase analysis in cell wall (Baytok et al., 2005). McDonald et al. (1991) reported that molasses is a stimulant fermentation additive because of containing sugar which utilize by microorganisms as the nutrition matter and increase their fermentation activity. Data of CP content showed that M5 lowered CP concentration significantly ($P<0.0001$) than other treatment. This result support previous study by Guo et al. (2007), who found that proteolysis may be increased by using molasses. It has been reported
that molasses as an additive to silages has high concentration of soluble carbohydrate that can stimulate heterofermentation process in silage but could not inhibit proteolysis enough (Aksu et al., 2006) due to slow reduction in pH with molasses addition (Baytok et al., 2005). The concentration of NH3-N in BP7.5 treated silage was significantly (P<0.0001) increased than that untreated silage. This may be affected by the higher pH of this silage than untreated silage. Slottner and Bertilsson, 2006 reported that deamination process decrease in low pH.

In situ Ruminal DM Digestibility

Coefficients and SEM of in situ ruminal DM degradability is presented in Table 2. In this study addition of the additives to silages affected in situ ruminal DM degradability of treated silages. The supplementation of MP10 and Molasses caused an increase in rapidly degradable fraction and BP7.5 and M5 caused to decrease in slowly degradable fraction. Molasses increase heterofermentation activity in silage (Aksu et al., 2006) and in this case Kung & Muck (1997) reported that decreases in fiber content may be due to partial acid hydrolysis of hemicellulose. Some data suggest that certain microbial activity can increase fiber digestion (Rice et al., 1990). Whoever in this study M5 treated silage has a lowest pH amongst all. On the other hand usually feeds which have lower coefficient a they have higher coefficient b. This finding supported previous data that found molasses-added silage had higher degradability of DM compared with control (Arbabi & Ghoorch, 2008). The coefficient c (The rate of degradation of part b) was the lowest in BP10 treatment in this study. In contrast with M5, the data of degradability coefficients of MP10 showed that although MP10 increased fraction of a, but the coefficient c was low. Therefore, As a whole M5 has a most effect on degradability fractions of a and b.

Table 1. Chemical composition of whole crop barley silage treated with sugar beet molasses or dried sugar beet pulp or Mixture of those.

<table>
<thead>
<tr>
<th>item</th>
<th>Fresh forage</th>
<th>Treatments¹</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UT</td>
<td>BP5</td>
<td>BP7.5</td>
<td>BP10</td>
<td>M5</td>
<td>MB5</td>
<td>MB10</td>
<td>s.e.m</td>
</tr>
<tr>
<td>pH</td>
<td>6.78</td>
<td>4.07b</td>
<td>4.11ab</td>
<td>4.04b</td>
<td>4.24a</td>
<td>3.70d</td>
<td>3.71cd</td>
<td>3.85c</td>
</tr>
<tr>
<td>NDF (g/kg DM)</td>
<td>640</td>
<td>0.55ab</td>
<td>0.53bc</td>
<td>0.56ab</td>
<td>0.59a</td>
<td>0.52bc</td>
<td>0.51c</td>
<td>0.52bc</td>
</tr>
<tr>
<td>CP (g/kg DM)</td>
<td>7.54</td>
<td>7.98ª</td>
<td>8.01ª</td>
<td>9.03ª</td>
<td>8.12ª</td>
<td>7.66ª</td>
<td>7.97ª</td>
<td>8.19ª</td>
</tr>
<tr>
<td>NH3-N (ml/dl)</td>
<td>--</td>
<td>9.1ª</td>
<td>10.04b</td>
<td>9.24ª</td>
<td>11.54ªa</td>
<td>8.02ªc</td>
<td>8.00ªf</td>
<td>8.03ªc</td>
</tr>
</tbody>
</table>

a,b,c,d:Means with different letters in the same row differed significantly at P< 0.05. ¹UT= untreated; BP5, BP7.5 and BP10= sugar beet pulp 50, 75 and 100 g/kg DM respectively; M5= Molasses 50 g/kg of DM; MB5 and MB10= mixture of dried sugar beet pulp plus sugar beet molasses 50:50 or 50:100 g/kg sugar beet molasses: dried sugar beet pulp, respectively. *: (P<0.0001)

Table 2. In situ dry matter degradable coefficients of whole crop barley silage treated with sugar beet molasses or dried sugar beet pulp or Mixture of those.

<table>
<thead>
<tr>
<th>Coefficients¹</th>
<th>UT</th>
<th>BP5</th>
<th>BP7.5</th>
<th>BP10</th>
<th>M5</th>
<th>MB5</th>
<th>MB10</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0.30±0.02</td>
<td>0.35±0.01</td>
<td>0.37±0.01</td>
<td>0.38±0.01</td>
<td>0.38±0.02</td>
<td>0.38±0.02</td>
<td>0.38±0.01</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>0.53±0.03</td>
<td>0.49±0.01</td>
<td>0.44±0.01</td>
<td>0.47±0.02</td>
<td>0.41±0.02</td>
<td>0.48±0.02</td>
<td>0.47±0.02</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>0.04±0.01</td>
<td>0.05±0.01</td>
<td>0.04±0.01</td>
<td>0.03±0.01</td>
<td>0.05±0.01</td>
<td>0.04±0.00</td>
<td>0.05±0.01</td>
<td></td>
</tr>
<tr>
<td>ED (0.02)</td>
<td>0.70</td>
<td>0.67</td>
<td>0.67</td>
<td>0.67</td>
<td>0.67</td>
<td>0.69</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>ED (0.04)</td>
<td>0.62</td>
<td>0.60</td>
<td>0.59</td>
<td>0.60</td>
<td>0.60</td>
<td>0.61</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>ED (0.06)</td>
<td>0.58</td>
<td>0.56</td>
<td>0.54</td>
<td>0.56</td>
<td>0.56</td>
<td>0.56</td>
<td>0.58</td>
<td></td>
</tr>
</tbody>
</table>

a,b:Means in each row with unlike superscript letters differ Significance at P< 0.05. ¹a= rapidly degradable, b= slowly degradable, c= fractional degradation rate constant. ED= a+(b×c)/ (k+c)) where k is the rumen outflow rate assumed to be 0.02, 0.04 or 0.06 h⁻¹.

Conclusions
It has been concluded that, from a silage fermentation standpoint, ensiling whole-crop barley with SM or BP offers the advantage of better silage fermentation and correspondingly higher ruminal degradability of DM. Use of molasses in WCBS can be an effective silage additive in terms of reducing silage pH that may be resulted from promoting lactic fermentation, and cause silages to be more stable. The degradability DM of feeds is one of important key variables for nutritive value in feeding systems. This parameter may be affected or limited by both diet DM and the rate at which that DM is digested in the rumen. This treatment lowered NDF content of silage and cause increase in rapidly degradable fraction a and decrease in slowly degradable fraction b of DM.

References


