Chemical composition and in situ dry matter degradation of whole crop barley silage treated with urea or anhydrous ammonia

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Abstract

Whole crop barley was harvested (32.5% DM), chopped, and then ensiled using laboratory silos (n= 4) as untreated (WCBS) or treated with urea (10, 20, 30 and 40 g/kg DM; WBSU1, WBSU2, WBSU3 and WBSU4, respectively) or anhydrous ammonia (10 and 20 g/kg DM; WBSA1 and WBSA2, respectively) for 30 days. Standard procedures were used to determine the chemical composition of the samples. The pH of the aqueous silage extract was determined using a pH meter. NH3-N concentration was determined in acidified silage extract (5 ml of the extract + 5 ml of 0.2 M HCl) using a distillation method. Four sheep (live weight: 44±3 kg) fitted with rumen fistulae were used. Approximately 5 g DM of each sample was placed in a polyester nylon cloth bag (10 x 12 cm, pore size of 52 μm, n=4), then incubated in the rumen for 0.0, 2, 4, 8, 16, 24, 48, 72 and 96 h. Rumen removal 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-ct) was applied to determine the coefficients (a= quickly degradable fraction, b= slowly degradable fraction, c= fractional degradation rate constant). Both urea and anhydrous ammonia caused a significant (P< 0.05) increase in silage pH and NH3-N, and CP concentrations. The slowly degradable fraction (b) of the silage treated with anhydrous ammonia was significantly (p< 0.05) higher than those of the untreated sample.

Keywords: whole crop barley silage, urea, ammonia, in situ degradability

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Summary

Whole crop barley was harvested (32.5% DM), chopped, and then ensiled using laboratory silos (n= 4) as untreated (WCBS) or treated with urea (10, 20, 30 and 40 g/kg DM; WBSU1, WBSU2, WBSU3 and WBSU4, respectively) or anhydrous ammonia (10 and 20 g/kg DM; WBSA1 and WBSA2, respectively) for 30 days. Standard procedures were used to determine the chemical composition of the samples. The pH of the aqueous silage extract was determined using a pH meter. NH3-N concentration was determined in acidified silage extract (5 ml of the extract + 5 ml of 0.2 M HCl) using a distillation method. Four sheep (live weight: 44±3 kg) fitted with rumen fistulae were used. Approximately 5 g DM of each sample was placed in a polyester nylon cloth bag (10 × 12 cm, pore size of 52 µm, n=4), then incubated in the rumen for 0.0, 2, 4, 8, 16, 24, 48, 72 and 96 h. Rumen removal 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-ct) was applied to determine the coefficients (a= quickly degradable fraction, b= slowly degradable fraction, c= fractional degradation rate constant). Both urea and anhydrous ammonia caused a significant (P< 0.05) increase in silage pH and NH3-N, and CP concentrations. The slowly degradable fraction (b) of the silage treated with anhydrous ammonia was significantly (p< 0.05) higher than those of the untreated sample.

Keywords: whole crop barley silage, Urea, Ammonia, in situ degradability.

Introduction

Ammonia and urea are practical and relatively inexpensive sources of non-protein nitrogen which can be used to increase the protein concentration of low protein forages such as cereal silage (Carr et al., 1984). Ammonia has been used as an additive in silage making mainly to improve the nitrogen content of the product (McDonald et al., 1991). NH3-N inhibit yeasts and molds and the NH3 treatment sialages markedly improved the stability and lowered the peak temperatures of aerated cereal silage due to its fungicidal properties, and thus increased bunk life. Ammonia toxicity is related to a high pH that maintained the undissociated form of NH3 which is toxic to fungal cells (DePasquale and Montville, 1990; McDonald et al., 1991). Adding urea to corn silage at ensiling can improve its relatively low protein content. Hence the aim of this study was to evaluate the effects of ensiling whole crop barley forage by addition of various amounts of urea and ammonia.

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 (WCBS) or treated with urea (10, 20, 30 and 40 g/kg DM; WBSU1, WBSU2, WBSU3 and WBSU4, respectively) or anhydrous ammonia (10 and 20 g/kg DM; WBSA1 and WBSA2, respectively) for 30 days.
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 (10×12 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 $P = a + b \left(1 - e^{-ct}\right)$ 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$^{-1}$. Data of silage chemical components (PH, NDF, NH3-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 whole crop barley silage (WCBS) are shown in Table 1. In the present study, the pH, NDF, CP and NH3-N was affected ($P<0.05$) when treatment was applied. The pH of silages treated with 30 or 40 g/kg DM increased significantly that agreed with Sarwatt et al. (1995) who stated that the addition of urea in cereal silages caused to increased pH. In this experiment the content of NDF lowered when urea was applied. This support previous data reported by Guney et al. (1970) primarily because of ammonia reduces plant proteolysis (Buchanan-Smith, 1982), forages treated with ammonia have been shown to be higher in insoluble N (Huber et al., 1979) and true protein. It has been previously shown that the addition of urea to cereal silages significantly increased CP content ($P < 0.01$). As expected, treatments increased the ammonia-N concentration in silage and were in part of supported by the high value of pH in these silages.

In situ Ruminal DM Digestibility
Degradable coefficients of DM of the samples are shown in Tables 2. Result, indicated that the slowly degradable fraction (b) of the silage treated with anhydrous ammonia was significantly higher than the untreated sample (p< 0.05). While urea increased the degradability of DM. Besides, Bolsen et al. (1996) have reported that urea and ammonia increases the digestibilities of DM, OM and cell wall components of silages (Budag et al., 1994). Previous study reported that the addition of anhydrous ammonia to forages increase the digestibility due to the solubilization of hemicellulose and delignification (Davis, 1980). Ammonia combines with the residual moisture in hay forming ammonium hydroxide that breaks the lignin-cellulose bonds in the cell walls of the forage. It also solubilizes some of the complex carbohydrates in the plant and swells plant fiber, thereby allowing for greater rumen microbial breakdown of the forage that caused to improvement in digestibility of forages (Kuhl, 1982). The coefficient b was high in treatment WBSU4 and WBSA2 while coefficient c was lower which can caused to slow analysis feeds into the rumen. In this case feeds remain into the rumen for a longer time and rate of pass decrease. These factors caused to more utilization of nutrients or potential of degradability of dry matter (a+b) in these silages. Data of this treatments showed that in situ ruminal DM digestibility of this treatments were higher than others that it due to more digestion nutrients (Nocek and Grant, 1987).

Table 1. Chemical composition of WCBS treated with urea or anhydrous ammonia.

<table>
<thead>
<tr>
<th>item</th>
<th>WCBS</th>
<th>WBSU1</th>
<th>WBSU2</th>
<th>WBSU3</th>
<th>WBSU4</th>
<th>WBSA1</th>
<th>WBSA2</th>
<th>S.E.M</th>
<th>P²</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.78</td>
<td>4.07</td>
<td>4.35</td>
<td>4.75b</td>
<td>7.10b</td>
<td>6.90</td>
<td>4.32</td>
<td>5.65</td>
<td>0.411 *</td>
</tr>
<tr>
<td>NDF (g/kg DM)</td>
<td>640</td>
<td>552a</td>
<td>550a</td>
<td>357ab</td>
<td>527b</td>
<td>507a</td>
<td>540ab</td>
<td>530b</td>
<td>7.63 **</td>
</tr>
<tr>
<td>CP (% DM)</td>
<td>7.54</td>
<td>7.98e</td>
<td>8.41e</td>
<td>9.02e</td>
<td>10.30b</td>
<td>11.27a</td>
<td>9.03d</td>
<td>9.82e</td>
<td>0.114 *</td>
</tr>
<tr>
<td>pH3-N (mld/l)</td>
<td>--</td>
<td>9.1f</td>
<td>26.8d</td>
<td>46.7e</td>
<td>80.2b</td>
<td>94.7a</td>
<td>17.6e</td>
<td>31.7d</td>
<td>3.59 *</td>
</tr>
</tbody>
</table>

a,b,c,d,e,f Means with different letters in the same row differed significantly at P<0.05; UT= untreated; WBSU1, WBSU2, WBSU3 and WBSU4 = urea 10, 20, 30 and 40 g/kg DM respectively; WBSA1 and WBSA2 = ammonia 10 and 20 g/kg DM respectively. **(P<0.0001); ***(P<0.01).

Table 2. In situ dry matter degradable coefficients of WCBS treated with urea or anhydrous ammonia.

<table>
<thead>
<tr>
<th>coefficients</th>
<th>WCBS</th>
<th>WBSU1</th>
<th>WBSU2</th>
<th>WBSU3</th>
<th>WBSU4</th>
<th>WBSA1</th>
<th>WBSA2</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0.30± 0.02</td>
<td>0.31± 0.01</td>
<td>0.31± 0.02</td>
<td>0.30± 0.01</td>
<td>0.32± 0.01</td>
<td>0.28± 0.02</td>
<td>0.28± 0.01</td>
</tr>
<tr>
<td>b</td>
<td>0.53± 0.03</td>
<td>0.52± 0.02</td>
<td>0.54± 0.02</td>
<td>0.56± 0.03</td>
<td>0.59± 0.03</td>
<td>0.56± 0.03</td>
<td>0.58± 0.03</td>
</tr>
<tr>
<td>c</td>
<td>0.04± 0.01</td>
<td>0.04± 0.01</td>
<td>0.03± 0.01</td>
<td>0.03± 0.01</td>
<td>0.02± 0.01</td>
<td>0.04± 0.01</td>
<td>0.03± 0.01</td>
</tr>
<tr>
<td>ED (0.02)</td>
<td>0.66</td>
<td>0.65</td>
<td>0.65</td>
<td>0.64</td>
<td>0.64</td>
<td>0.64</td>
<td>0.60</td>
</tr>
<tr>
<td>ED (0.04)</td>
<td>0.58</td>
<td>0.56</td>
<td>0.56</td>
<td>0.54</td>
<td>0.54</td>
<td>0.54</td>
<td>0.50</td>
</tr>
<tr>
<td>ED (0.06)</td>
<td>0.52</td>
<td>0.51</td>
<td>0.50</td>
<td>0.49</td>
<td>0.49</td>
<td>0.49</td>
<td>0.45</td>
</tr>
</tbody>
</table>

a,b Means in each row with unlike superscript letters differ Significance at P<0.05.

Data of the present study indicated that the use of urea or anhydrous ammonia in WCBS caused to increase the pH and NH3-N concentration. This findings support the results of Kung et al. (2000) and Hill and Leaver (2002). Applying this kind of additives in WCBS had a benefit when in situ DM degradation was considered. Present demonstrated that the DM degradable coefficients of WCBS were improved when treated with urea or anhydrous ammonia. This effect might be due to the microbial attachment and cell wall degradation of

Conclusions
whole crop cereal silage as reported by Hill and Leaver (2002). As a whole of finding the present study, satisfied silages were obtained in terms of fermentation properties and in situ DM degradability.

References


