Can apples be used as a source of fermentable carbohydrate when making alfalfa silage?

T. GÜLER*, I.H. ÇERÇI, M. ÇIFTÇI and O.N. ERTAS

Department of Animal Nutrition, Faculty of Veterinary Sciences, University of Firat, 23119 Elazığ, Turkey

* Corresponding author: E-mail: tguler@firat.edu.tr - talatguler@yahoo.com

SUMMARY

The aim of the current experiment was to explore the possibility of substituting barley grain or sucrose, which are traditionally used as carbohydrate sources in silage making, with inedible apples (unfit for human consumption). Alfalfa silages were made with the following additives: control group (no additive), A-1 group with 1% sucrose, A-2 group with 2% sucrose, A-5 group with 5% barley grain, A-10 group with 10% barley grain, B-5 group with 5% apple and B-10 group with 10% apple. The silos were opened after 2 months of fermentation and the quality of the silages, changes in their physical aspect, fermentation products and rumen dry matter and crude protein degradability were assessed. Silages were evaluated physically; all treatments tested produced good quality silage, while the control was of average quality. Dry matter was highest in the B-10 group silage (p<0.05). Ash, crude protein, ether extract and crude fiber were similar in the test groups and were higher than in their corresponding fresh material (alfalfa before ensiling), while nitrogen free-extract levels were higher in fresh material. The highest pH was found in the control group (p<0.05) and was not different between test groups. The lowest lactic acid level was found in the control group (p<0.05), and it was not different between test groups. NH₃-N levels were similar in all the groups. In conclusion, high-sugar containing fruit, such as apples, can be added to alfalfa silages as a carbohydrate source, therefore ensuring adequate fermentation during the ensiling process.

Keywords: Alfalfa silage - apple - barley - sucrose - silage quality.

Introduction

Alfalfa (Medicago sativa), often called the queen of feed plants due to its high nutrient content, is generally used as hay. However, large amounts of nutrients can be lost due to mechanical effects during the drying and storage processes [16, 18, 26]. Recently, alfalfa has started to be used as silage in addition to hay due to improvements in mechanization, lower field losses and reduced weather damage [5]. In particular cut alfalfa has been evaluated as silage especially in rainy regions [8]. It is difficult to ensile alfalfa due to its nutrient composition (high in protein, moisture and buffering capacity and low in readily fermentable carbohydrates) [13, 15] and therefore silage made from alfalfa is generally of poor quality. For this reason, during silage making, carbohydrate additives can be used to ensure optimal fermentation [9, 24].

Different additives such as grains, molasses, sugar, etc. are used during silage making and they are generally used to increase the amount of readily fermentable carbohydrate [13, 15]. Fruit pulp is also rich in readily fermentable carbohydrates but its use as a silage additive has generally been overlooked [4, 5, 17]. A considerable amount of inedible fruit (unfit for human consumption) is obtained during the harvesting period. An example of this type of fruit is the apple which contains about 12 % carbohydrate, most of which is in the form of readily fermentable carbohydrates such as glucose, fructose and sucrose [28]. Therefore, whole apple might be used as a source of carbohydrate in silage making, especially alfalfa silage. In a literature search, we were not able to find any studies on the use of apple as a silage carbohydrate additive. Therefore, the aim of the current experiment was to explore the possibility of substituting barley grain or sugar, traditionally used as carbohydrate sources in silage making, with non-edible apples and to determine its effect on silage quality and rumen dry matter and crude protein degradabilities.

RéSUMÉ

Les pommes peuvent-elles constituer des sources de glucides fermentables durant la préparation de l’ensilage de luzerne ? Par T. GÜLER, I.H. ÇERÇI, M. ÇIFTÇI et O.N. ERTAS.

L’objectif de cette étude est d’évaluer les possibilités de substitution de l’orge en grains ou du saccharose, traditionnellement utilisés comme sources de glucides dans l’ensilage, par des pommes non consommables (pour l’homme). Les ensilages de luzerne ont été préparés avec ou sans additif : groupes contrôle (o additive), S1 (saccharose 1%), S2 (saccharose 2%), B5 (grains d’orge 5%), B10 (grains d’orge 10%), A5 (pomme 5%), A10 (pomme 10%). Les silos ont été ouverts après une fermentation de 2 mois. La qualité des ensilages, leurs changements physiques, les produits de fermentation et la dégradation ruminale de la matière sèche et des protéines brutes ont été mesurés. Tous les traitements testés ont produit des ensilages de qualité alors que l’ensilage contrôle a montré une qualité moyenne. La proportion de matière sèche a été la plus élevée dans le groupe B10 (p < 0.05). Les proportions de minéraux, de protéines brutes, de l’extraire par l’éther, et de fibres brutes ont été identiques dans les différents groupes et se sont avérées plus élevées après l’étape de fermentation alors que les proportions d’extraits non azotés étaient plus élevées dans la luzerne avant fermentation. Les valeurs de pH les plus élevées et les concentrations d’acide lactique les plus faibles ont été observées dans l’ensilage contrôle (p < 0.05), alors que dans les autres types d’ensilage, ces valeurs sont restées comparables. Les proportions de NH3 ont été identiques dans tous les groupes. En conclusion, les fruits à forte teneur en sucres comme les pommes peuvent être ajoutés à la luzerne en tant que sources de glucides, permettant ensuite une fermentation correcte durant la préparation de l’ensilage.

Materials and methods

SILAGE MATERIALS AND EXPERIMENTAL GROUPS

Fifth cut alfalfa was harvested at the pre-flowering stage of maturity in October. The alfalfa was ensiled in plastic silos (2 kg) and carbohydrate sources were added as follows: Control group (with no additive), S-1 (1% sucrose), S-2 (2% sucrose), B-5 (5% barley grain), B-10 (10% barley grain), A-5 (5% apple) and A-10 (10% apple). The alfalfa was chopped with a cutter (approximately 1.5-2 cm) and sucrose, barley grain or apples were added to the alfalfa on a nylon ground cloth. Sucrose was added as a powder whereas barley grain was added after grinding and whole apple was added after being chopped by a mixer. The sucrose, barley grain or apples were thoroughly mixed with the alfalfa. The mixtures were placed in plastic silos by hand. Each treatment had six replicates. The silos were opened after 2 months of fermentation and physical characteristic, chemical composition, fermentation products, in situ rumen dry matter and crude protein degradability were determined.

In order to estimate the physical characteristics, silages were spread over a nylon cloth and odor, structure and color were noted [1]. (Evaluation: 16-20 total points = very good quality; 10-15 total points = good quality; 5-9 total points = average quality; 0-4 total points = bad quality). The Flieg point was calculated using the following formula [1].

Flieg point = 205 + (2 x DM% - 15) - 40 x pH, (Evaluation : 81-100 points, very good quality ; 50-80 points, good quality and < 50 points, bad quality).

IN SITU DIGESTION

Three rams (2 years old and 55-60 kg Body Weight) fitted with rumen cannulas were used in this experiment. The operations were performed at the Veterinary Faculty of Firat University (Elazığ, TURKEY). Ruminal cannulas were fitted 1 month before the experiment started. The cannula was inserted into the paralumbal fossa under local anesthesia using a two-step procedure. The first step consisted of removing a circular piece of skin, approximately 7-8 cm in diameter, dissecting the underlying muscle and the peritoneum, and suturing the wall of the rumen to the skin. The exposed ruminal wall was scrubbed with saline every day for 7 day. One week later, the exposed ruminal wall was necrosed, and it was removed with a scalped before inserting the ruminal cannula. A 5-ml, i.m. injection of penicillin was given on the morning of the first step of the procedure and for 3 days thereafter. The rams were cared for according to the guidelines of the Canadian Council on Animal Care [6]. The rams were fed with 900 g alfalfa hay and 300 g concentrate according to ORSKOW et al. [19]. The concentrate contained 50 % barley, 25.5 % sunflower seed meal, 21.5 % wheat bran, 1 % salt, 1 % dicalciumphosphate, 0.5 % vitamin premix and 0.5 % mineral premix. Animals were fed twice daily (09h00 and 16h00).

Nylon bags were used for the in situ dry matter and crude protein degradability. Bags measured 70x110 mm with an average pore size of 40 µm. Five grams of each sample, ground to pass a 2.5 mm screen, were weighed into bags. Bags were tied with a nylon cord and attached to a weighed plastic chain (of about 30-35 cm). Duplicate bags were incubated in the rumen for 4, 8, 16, 24, 48, 72 and 96 h. All bags were placed into the rumen simultaneously and removed after the specified time. After removal from the rumen, bags were rinsed under cold tap water to remove particles adhering to the outside of the bag and washed twice with cold water on gentle cycle in a washing machine. Washed bags were dried at 60° C for 48 h and weighed, and dry matter (DM) and crude protein (CP) were determined on the residue. Rumen DM and CP degradability were calculated using the following formula:

Dry matter (DM) degradability, (%) = 100 - [(D3 - D1/ D2 - D1) x 100];

Where: D1 is the weight of the bag (g), D2 is the weight of the bag + sample (g) before incubation, D3 is the weight of the bag + sample (g) after incubation.

Crude protein (CP) degradability, (%) = [(a - b) / a] x 100;

Where: a is CP level (g) before incubation; b is CP level (g) after incubation.

CHEMICAL ANALYSIS

Dry matter, crude protein, ash and ether extract in fresh material and in silages were analyzed using AOAC procedures [3]. Crude fiber was determined by the method of CRAMPTON and MAYNARD [7]. The pH level in silages was determined by a pH meter (Beckman-Zeromatic SS-3, Beckman Instruments Inc. California, U.S.A.). The lactic acid level in the silages was determined according to the method of PETIT and FLIPO [20], while the NH3-N level in the silages was determined according to the method of ANNINO [2].

STATISTICAL ANALYSIS

The data collected were subjected to analysis of variance. When significant differences were observed, means were further subjected to Duncan’s multiple range test, SPSS for Windows : 10.1, SPSS inc., [22]. The results were considered as significant when p values were less than 0.05.

Results

Nutrient Contents: The levels of ash, crude protein, crude fiber and ether extract in the silages were higher than in the fresh material (alfalfa before ensiling) whereas nitrogen free extract was lower (Tables I and II).

Silage characteristics: The levels of ash, crude protein, crude fiber, ether extract and nitrogen-free extract in the silages were similar, while dry matter was significantly affected by treatment (Table II). The highest dry matter was found in B-10 followed by B-5, A-10, S-2, A-5, S-1 and control respectively (p<0.05). Silages were evaluated physically; all treatments produced good quality silage while the control group was of average quality (Table III).

**Fermentation products in silages:** pH values in the test groups were similar and lower than the control group (Table IV) (p<0.05), while lactic acid levels in the test groups were similar and higher than the control group (p<0.05). NH₃-N levels were not different between groups (p>0.05). The use of carbohydrate sources in silages decreased the pH value and increased the lactic acid concentration, while it did not affect the concentration of NH₃-N.

**In situ digestion:** Rumen dry matter (Table V) and crude protein (Table VI) degradability were not affected by treatment (p>0.05).

**Discussion**

Alfalfa is a very important feedstuff in animal nutrition and commonly used throughout the world. Alfalfa is gene-
rally fed to herbivores either fresh or as hay. Final cut alfalfa has been used as silage especially in rainy regions where it is not possible to dry hay [8]. For this reason, during silage making, additives are required to increase the carbohydrate level in the silo. In this study, we aimed to determine the conservation characteristics of alfalfa silages following the addition of different carbohydrate sources to supply a substrate for bacterial growth.

Silages were evaluated physically, the Flieg point (defined in material and methods) was higher in all groups with added carbohydrate compared to the control group (p<0.01). The difference between treatments and control may be due to differences in silage pH and dry matter. Similarly, while the silages in the treatment groups were of good quality, the control silage was of average quality. Therefore, the supplementation with carbohydrate sources improved alfalfa silage quality.

The highest silage dry matter was found in B-10 followed by B-5, A-10, S-2, A-5, S-1 and the control respectively (p<0.05). The reason for this might be related to the quantity of carbohydrate added to the silage. Indeed, more the sucrose was concentrated in dry matter and more the silage additive contains dry matter, more dry matter would increase in silage materials after fermentation. Ash, crude protein, ether extract and crude fiber were similar in all silages treated by carbohydrate and higher than in the respective fresh material. These results are in agreement with the literature [12, 14]. Nitrogen-free extract levels in silages were lower than in the respective fresh material [12, 21]. This is probably the result of consumption of nitrogen-free extract by microorganisms during fermentation.

The highest pH value was measured in the control group (p<0.05). Control: No additive carbohydrate source, S-1: 1% sucrose, S-2: 2% sucrose, B-5: 5% barley, B-10: 10% barley, A-5: 5% apple, A-10: 10% apple.

| TABLE IV. — The effect of different carbohydrate sources on fermentation products in alfalfa silages after 2 months of fermentation, (n=6). |
| Control | S-1 | S-2 | B-5 | B-10 | A-5 | A-10 | SEM | P value |
| pH | 5.35 \textsuperscript{a} | 4.38 \textsuperscript{b} | 4.28 \textsuperscript{b} | 4.45 \textsuperscript{b} | 4.33 \textsuperscript{b} | 4.45 \textsuperscript{b} | 4.35 \textsuperscript{b} | 0.13 | 0.005* |
| Lactic acid, % DM | 3.86 \textsuperscript{a} | 5.98 \textsuperscript{b} | 6.21 \textsuperscript{b} | 5.86 \textsuperscript{b} | 6.05 \textsuperscript{b} | 5.78 \textsuperscript{b} | 6.11 \textsuperscript{b} | 0.87 | 0.006* |
| NH\textsubscript{3}-N, % DM | 0.62 | 0.60 | 0.55 | 0.58 | 0.61 | 0.54 | 0.59 | 1.23 | 0.484 |

\( \ast \) : p<0.05, \( \text{a,b} \) : Mean values with different superscripts within a row differ significantly.

TABLE V. — The effect of different carbohydrate sources added to alfalfa silages after 2 months of fermentation on rumen dry matter degradability, (n=6).

<table>
<thead>
<tr>
<th>4 h incubation</th>
<th>8 h incubation</th>
<th>16 h incubation</th>
<th>24 h incubation</th>
<th>48 h incubation</th>
<th>72 h incubation</th>
<th>96 h incubation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>S-1</td>
<td>S-2</td>
<td>B-5</td>
<td>B-10</td>
<td>A-5</td>
<td>A-10</td>
</tr>
<tr>
<td>pH</td>
<td>57.40</td>
<td>58.41</td>
<td>57.45</td>
<td>57.98</td>
<td>58.35</td>
<td>59.12</td>
</tr>
<tr>
<td>Lactic acid, % DM</td>
<td>70.00</td>
<td>69.86</td>
<td>72.05</td>
<td>70.38</td>
<td>69.45</td>
<td>70.50</td>
</tr>
<tr>
<td>NH\textsubscript{3}-N, % DM</td>
<td>83.15</td>
<td>81.32</td>
<td>82.28</td>
<td>82.00</td>
<td>81.96</td>
<td>82.30</td>
</tr>
</tbody>
</table>

Control: No additive carbohydrate source, S-1: 1% sucrose, S-2: 2% sucrose, B-5: 5% barley, B-10: 10% barley, A-5: 5% apple, A-10: 10% apple.
Can apples be used as a source of fermentable carbohydrate when making alfalfa silage?

Hydrates in the silo. Lactic acid levels were found to be lower in the control than the test groups (p<0.05). Lactic acid levels in the test groups were similar, but higher in S-2, B-10, and A-10 groups than S-1, B-5, and A-5 groups, according to the level of carbohydrate added. The NH₃-N concentration was found to be similar in all groups. In other studies, similar findings were observed. STALLINS et al. [23] reported that the addition of 1% arabinose and 1% glucose to alfalfa reduced pH and increased silage quality. Similarly, UMANA et al. [27] reported that the addition of 5% molasses to Bermuda grass increased lactic acid levels and silage quality. In the same type of experiment, in order to ensure optimal fermentation, ÇERÇI et al. [9] added 5% barley to corn silage, and 1% and 1.5% sucrose to barley silage [10], and 0.5% sucrose to corn silage [11]; TATLI et al. [25] added 0.5% sucrose to barley and oat silages. Similarly, ÇERÇI et al. [6], made silages by mixing corn and alfalfa. They increased the amount of added sucrose as the proportion of alfalfa increased: 0.5% sucrose to the group containing 25% alfalfa, 1% sucrose to the group containing 50% alfalfa and 1.5% sucrose to group containing 75% alfalfa. Sucrose can be stored but is expensive, while barley is relatively cheap and can be stored for a long time. Normally unmarketable inedible apples can be used as an alternative to traditional sources of carbohydrate such as barley grain and sucrose. In normal conditions due to high moisture and sucrose levels, it requires cold storage if it is to be kept a long time (but this procedure increases cost).

Dry matter degradability at 4, 8, 16, 24, 48, 72 and 96 h after feeding was found to be similar for all groups (p>0.05). This result may be due to the similar nutrient levels of the silages. Nitrogen free extract would have a positive effect on digestibility, while crude fiber would have a negative effect on digestibility. Crude protein degradability at 4, 8, 16, 24, 48, 72 and 96 h after feeding was found to be similar for all groups (p>0.05) and is probably related to the similar chemical compositions of the silages. In conclusion, when making alfalfa silage, which is regarded as one of the most difficult plants to ensile, it is necessary to add readily fermentable carbohydrates. Unmarketable inedible apples can be used as an alternative to traditional sources of carbohydrate such as barley grain and sucrose.

References