

Modified Atmosphere to Reduce Proteolysis in Alfalfa Silage

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Introduction

Alfalfa is now commonly conserved as silage. While ensiling has many advantages, one particular problem is the breakdown of true protein to soluble nonprotein nitrogen (NPN). In alfalfa silage, soluble NPN typically accounts for 50 to 70% of total nitrogen. This loss of true protein makes it more difficult to develop a ration where the nitrogen will be utilized efficiently by cattle, and leads to excess excretion of nitrogen in manure.

Currently, there are no cost-effective methods of preserving true protein in alfalfa during ensiling. Modified atmospheres, containing nitrogen, carbon dioxide and low levels of oxygen, have been used to maintain fruit and vegetable quality by minimizing respiration but keeping enough oxygen present to keep cells intact. Such success with preserving fruits and vegetables suggested that a modified atmosphere (MA) might preserve protein in silage, and this was shown in earlier research at the Center. The studies reported here were performed to further understand and potentially enhance the benefits of modified atmosphere on protein preservation in alfalfa.

Methods

Three experiments were performed. Treatments in the first two experiments were similar, but one was conducted on direct-cut alfalfa and the other on wilted alfalfa. The alfalfa was ensiled in 31 PVC silos. Half the silos were ensiled normally under anaerobic conditions and the other half were maintained under MA (3% O₂, 12% CO₂, 85% N₂). For both atmospheric conditions, there were four treatments: control, sugar addition at 5% DM, ammonium hydroxide addition at 0.8% DM, and reduced temperature. All silos were emptied and analyzed after 7 d.

In the third experiment, the length of MA exposure was investigated. Direct-cut alfalfa was ensiled in pint glass jars. Six treatments were imposed: normally ensiled or MA for 1, 2, 3, 5 or 7 d. For the various

MA exposure times, two normally ensiled and two MA silos were opened and analyzed for quality and cell viability. The remaining contents of the MA silos were reensiled and allowed to go anaerobic. An additional two MA silos were opened after 3 and 7 d, inoculated with lactic acid bacteria at 10⁵ cfu/g crop, reensiled and allowed to go anaerobic. After a total storage period of 28 d, silos of all treatments were opened for sampling and analysis.

Results

Modified atmosphere reduced soluble NPN (Tables 1 and 2) and improved protein preservation in all three experiments. However, in experiments 1 and 2, there was extensive mold growth and high pHs in the MA alfalfa after seven days storage. In the third experiment, no mold growth was observed in the MA alfalfa. In that experiment, pH and DM contents were generally similar to initial conditions for the first 3 days. Thereafter, DM content decreased and pH increased in the MA alfalfa indicating increasing respiration losses. Such changes coincided with the loss of cell viability in the MA treatments between days 2 and 3 (Fig. 1).

In experiments 1 and 2, the sugar and ammonia treatments did not significantly reduce soluble NPN (Table 1) or improve protein preservation in either the normally ensiled or MA alfalfa. Low temperature reduced soluble NPN in the direct-cut alfalfa, particularly in the MA alfalfa. Similar trends were observed in the wilted alfalfa, but they were not statistically significant.

When the MA treatments in experiment 3 were reensiled, little or no fermentation was evident after 28 d of storage. The only reductions in pH occurred in the 1-day MA treatment. Inoculation of the 3-day and 7-day treatments with lactic acid bacteria produced no difference in pH relative to the corresponding uninoculated MA treatments. These results suggest that the MA treatment resulted in the production of compounds that inhibited lactic acid bacterial growth.

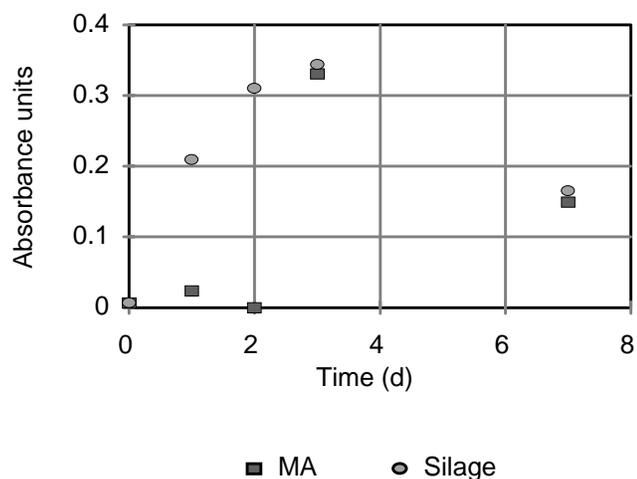


Figure 1. Absorbance of Evans Blue (an indicator of cell viability) by alfalfa cells from MA and silage treatments in Experiment 3.

Conclusions

Modified atmosphere was able to enhance protein preservation in all three experiments. However, our results suggest that MA treatment needs to be limited to early in ensiling. MA was capable of extending cell viability in the silo for two to three days and in this period little DM loss occurred. There was no benefit to extending the MA beyond this period as longer treatment times increased DM losses substantially and increased the probability for the development of spoilage microorganisms such as molds. More research is needed to develop optimum schemes that promote both protein preservation and a normal fermentation.

Table 1. Soluble NPN (% total N) in alfalfa silages in Experiments 1 and 2.

Atmosphere	Control	Sugar	Ammonia	Low Temp	SEM	Significance	
						MA	Treatment
Experiment 1 (alfalfa at 17% DM)							
Silage	50.2	56.0	58.9	46.9	5.5	***	**
MA	36.7	39.6	49.3	19.0			
Experiment 2 (alfalfa at 64% DM)							
Silage	22.4	18.7	24.2	20.7	2.5	*	NS
MA	17.3	16.9	22.9	13.3			

*** = P<0.001, ** = P<0.01, * = P<0.05, NS = not significant

Table 2. Soluble NPN (% total N) in alfalfa silages (20% DM) in Experiment 3.

Atmosphere	Day 1	Day 2	Day 3	Day 5	Day 7	SEM	Significance	
							MA	Day
Silage	35.6	40.1	52.8	49.9	55.0	3.2	***	***
MA	16.0	22.2	26.9	26.1	37.8			