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Nutritive value and fermentation characteristics of alfalfa-mixed grass forage wrapped with minimal stretch film layers and stored for different lengths of time

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ABSTRACT

A key aspect of managing baled silages is to quickly achieve and then rigorously maintain anaerobic conditions within the silage mass. The concept of inserting an O_2-limiting barrier (OB) into plastic commercial silage wraps has been evaluated previously, yielding mixed or inconclusive results. Our objective for this study was to maximize the challenge to a commercial polyethylene bale wrap, or the identical wrap containing an OB, by using minimal plastic (4 layers), and then extending storage periods as long as 357 d. Forty-eight 1.2 × 1.2-m large-round bales of alfalfa (*Medicago sativa* L.) and mixed grass forage (66.3 ± 8.66% alfalfa; DM basis) were made at 2 moisture concentrations [47.5 (ideal) or 36.1% (dry)], wrapped with 4 layers of plastic containing an OB or no OB, and then stored for 99, 243, or 357 d. After storage, yeast counts within the 0.15-m deep surface layer were not affected by treatment (mean = 5.85 $\log_{10}$ cfu/g); mold counts could not be analyzed statistically because 26 bales were nondetectable at a 3.00 $\log_{10}$ cfu/g detection limit, but means among detectable counts were numerically similar for OB (4.74 $\log_{10}$ cfu/g) and no OB (4.77 $\log_{10}$ cfu/g). Fermentation characteristics were most affected by initial bale moisture, resulting in a more acidic final pH for ideal compared with dry bales (5.52 vs. 6.00). This was facilitated by greater concentrations of total fermentation acids (3.80 vs. 1.45% of dry matter), lactic acid (2.24 vs. 0.71% of dry matter), and acetic acid (1.07 vs. 0.64% of dry matter) within ideal compared with dry silages. Plastic wrap type had no effect on final concentrations of any fermentation product. During fermentation and storage, we noted greater change in concentrations of fiber components and whole-plant ash within the 0.15-m deep surface layer than in the bale core, and these changes always differed statistically from 0 (no change) based on pre-ensiled baseline concentrations. Overall, concentrations of water-soluble carbohydrates were reduced (mean = 2.3 percentage units) during fermentation and storage, which resulted (indirectly) in increased concentrations of fiber components and crude protein, as well as an overall energy cost of 2.2 percentage units of total digestible nutrient. It remains unclear under what conditions an OB plastic wrap will consistently benefit the fermentation and preservation of baled silages.
Key words: alfalfa, baled silage, fermentation, polyethylene layers, nutritive value

INTRODUCTION

Although the production of baled silages has become increasingly popular, particularly with small- and mid-sized dairy or beef producers, some management considerations differ from those of traditional precision-chopped silages. Recommendations for a target moisture concentration for baled silages (45 to 55%; Shinners, 2003) are substantially drier than those described commonly for precision-chopped silages, such as alfalfa (*Medicago sativa* L., ≤70%; Muck et al., 2003). One net effect of these differences in recommended moisture concentrations is that fermentation of baled silages is inherently restricted compared with chopped silages, thereby limiting the production of fermentation acids as well as the associated pH depression within the silage mass (Nicholson et al., 1991). Normally, a low final pH is considered important because it provides stability to the silage, and ensures that problematic secondary fermentations by clostridia are inhibited. However, this disadvantage in managing baled silages can be offset by decreasing the moisture concentration of the silage, which also exhibits an inhibitory effect on clostridial fermentations (McDonald et al., 1991). Because baled silages are drier, exclusion of oxygen is critically impor-

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tant for preservation. The permeability of plastic films to O_2 has the potential to increase aerobic deterioration by stimulating proliferation of aerobic microorganisms, such as yeasts and molds, whose growth also may be stimulated by unfermented sugars that are present in greater concentrations when fermentation is restricted by field wilting (McDonald and Edwards, 1976).

Several studies have evaluated various approaches for limiting oxygen permeability through polyethylene silage wraps. Hancock and Collins (2006) evaluated the number of polyethylene wrapping layers on the subsequent preservation of baled alfalfa silage and determined that more than 2 polyethylene layers are needed for consistent preservation of baled alfalfa; however, little advantage was generally associated with more than 4 layers following a 5-mo storage period. Similarly, Keles et al. (2009) concluded that 2 plastic wrapping layers resulted in inferior preservation, reduced digestibility, extensive mold growth, and deteriorated perennial ryegrass (*Lolium perenne* L.) baled silage in Ireland. However, these problems were largely remedied by using 4 plastic layers, and little further improvement was observed by increasing plastic usage to 6 layers. In a previous study conducted at our location (Coblentz et al., 2016b), it was concluded that 4 polyethylene layers may ensure acceptable fermentation, but the risk of internal puncture by alfalfa stems during handling or storage may be unacceptable to many producers. Based on visual observations made in that study, 4 polyethylene layers likely represents the practical minimum to obtain an acceptably fermented and preserved baled silage, but additional layers may be desirable to ensure the integrity of the plastic, especially when forages have rigid physical characteristics, such as those of alfalfa stems.

Another approach to limiting oxygen permeability through the polyethylene wrap is to embed an O_2-limiting barrier (**OB**) within the plastic. Borreani and Tabacco (2008) observed that insertion of an OB within the polyethylene wrap reduced losses of DM during storage, as well as visual estimates of surface mold cover, and may encourage reduced plastic usage, while maintaining good fermentation and storage characteristics. Similar improvements in preservation were found in subsequent studies by the same group (Borreani and Tabacco, 2010) and following meta-analysis of OB used with a variety of silo types (Wilkinson and Fenlon, 2013). However, other studies have been inconclusive (Coblentz et al., 2016a) or have reported inconsistent improvements of yeast and mold counts at the bale surface compared with no OB (Coblentz et al., 2016b). Our objectives for the current study were to maximize the challenge to a prototype polyethylene bale wrap containing an OB compared with an identical plastic wrap containing no OB (**SUN**) by using minimal plastic (4 layers) and extended storage periods (99, 243, or 357 d) that transcended the winter months in central Wisconsin. The integrity of silage plastic wraps was further challenged by making bales within typical recommendations for moisture (47.5%), but then further wilting to 36.1% moisture, which is drier than suggested by Shinners (2003).

MATERIALS AND METHODS

Description of Field Site and Experimental Layout

A field site planted with Nexgrow 6422Q alfalfa (Forage Genetics International, Nampa, ID) and Alfamaster mixed grasses (Barenbrug USA, Tangent, OR) located on the University of Wisconsin Marshfield Agricultural Research Station (44°39′N, 90°08′W) was selected for the experiment. The alfalfa/grass mixture was established on May 16, 2013, at respective seeding rates of 5.2 and 3.0 kg/ha for the individual alfalfa and mixed grass components of the sward. The alfalfa/mixed grass sward was harvested to a 7.5-cm stubble height with a Case-International Harvester Model 8830 mower-conditioner (J. I. Case Co., Racine, WI) equipped with a sickle-bar cutting mechanism and metal conditioning rollers at 0900 h on June 30, 2015. The maximum cutting width of the mower-conditioner was 3.7 m, and the mean swath width was 2.41 ± 0.036 m. At harvest, the alfalfa component of the stand was at the full-flower stage of growth. Prior to baling, a trained technician walked each of 4 field blocks in a zig-zag pattern collecting random grab samples (~1,300 g/block; wet basis) to determine percentages of alfalfa and mixed grass within each block, forages were separated by hand, dried to constant weight under forced air at 55°C, and percentages of alfalfa and mixed grass calculated on a DM basis (66.3 and 33.7 ± 8.66%, respectively).

Mowed forage was allowed to wilt, undisturbed, until baling began at 1100 h on July 2. A total of 48 1.2 × 1.2-m large-round bales were made for this study; 24 bales (6 bales/block) were made at a moisture concentration considered ideal for round-bale silage (47.5%, ideal), whereas the remaining 24 bales were made at 1530 h after the moisture concentration was reduced by additional wilting to 36.1% (dry). A New Holland Roll-Belt 450 round baler (CNH America LLC, Racine, WI) was used to bale all forages in the trial in long-stem form. Each bale was tied upon exit from the bale chamber with 2 revolutions of net wrap. For this research site, there was little obvious reason to suspect topographical variation across field blocks; however,