J. Dairy Sci. 88:1815–1826

Aerobic Stability of Wheat and Orchardgrass Round-Bale Silages During Winter*

R. T. Rhein, W. K. Coblentz, J. E. Turner,† C. F. Rosenkrans, Jr., R. K. Ogden, and D. W. Kellogg
Department of Animal Science, University of Arkansas, Fayetteville 72701

ABSTRACT

Using recently developed technology, balage is often stored in large (1.2 × 1.2 m) round bales that are wrapped in plastic film with an in-line wrapper. The aerobic stability of this fermented forage is important, particularly during winter months when it is fed to livestock or sold as a cash crop. Two types of forage, orchardgrass [*Dactylis glomerata* L.; 54.4% dry matter (DM)] and wheat (*Triticum aestivum* L.; 62.4% DM), were packaged in large round bales and wrapped with an in-line wrapper during May 2002. Twenty-one bales of each balage type were unwrapped and exposed to air on Dec. 10, 2002 for 0, 2, 4, 8, 16, 24, or 32 d (ambient temperature range = 0.6 to 19.4°C) to evaluate aerobic stability. For both orchardgrass and wheat balage, final bale weight, concentration of DM, and pH were not affected by exposure time. Across both balage types, DM recoveries were ≥97% for all bales, indicating that both balage types were very stable when exposed to air. For orchardgrass balage, exposure time had no effect on concentrations of NDF, ADF, hemicellulose, cellulose, or lignin, thereby indicating that little deterioration occurred. Similarly, no contrast relating any fiber component with exposure time was significant for wheat balage. Concentrations of crude protein (CP) were not affected by exposure time for wheat balage, but there was a tendency for exposed orchardgrass bales to have greater concentrations of CP than bales sampled on d 0. Exposure time had no effect on 48-h in situ digestibility of DM for wheat balage, but there was a tendency for a linear increase with exposure time for orchardgrass balage. However, the overall range (78.2 to 80.5%) over the 32-d exposure period was very narrow, and this response is probably of limited biological significance. Generally, concentrations of fermentation acids were low, primarily because of the high concentration of DM within these balages, and only minimal changes in these acids were observed over the exposure interval. These results suggest that the balage evaluated in this trial during winter conditions was very stable after exposure to air for up to 32 d. This should allow for considerable flexibility with respect to feeding, transport, and marketing of balage during winter months without significant aerobic deterioration.
(**Key words:** aerobic stability, balage, orchardgrass, round-bale silage)

INTRODUCTION

In the Upper South, the storage of harvested forages as fermented silage has several advantages over storage as dry hay. A primary advantage is associated with the unstable weather conditions that often occur throughout this region in the spring. Typical weather patterns in April, May, and early June are often rainy with cool temperatures. Normal precipitation levels in Fayetteville, Arkansas, during April, May, and June are 110, 129, and 134 mm, respectively (NOAA, 2002). This increases drying time and makes it very difficult to achieve the level of dehydration necessary for safe storage as dry hay for cool-season annual or perennial grasses, such as wheat, cereal rye (*Secale cereale* L.), oat (*Avena sativa* L.), annual ryegrass (*Lolium multiflorum* Lam.), orchardgrass, or tall fescue (*Festuca arundinacea* Schreb.). The threshold concentration of DM for satisfactory storage of dry hay is approximately 80% DM for conventional rectangular bales (Collins et al., 1987), but large round bales are more prone to spontaneous heating (Montgomery et al., 1986) and need to be drier (82 to 84% DM) for safe storage. The negative consequences of baling hay before it is dried adequately are widely known to producers; they include molding, spontaneous heating, undesirable changes in forage quality, and potential for spontaneous combustion (Rotz and Muck, 1994; Coblentz et al., 2000; Turner et al., 2002).

As a result of these factors, producers are often faced with the choice of baling hay before it is dried adequately or risking damage to the wilting forage by rainfall events. When rainfall events occur before baling,

Received August 13, 2004.
Accepted November 19, 2004.
Corresponding author: W. K. Coblentz; e-mail: coblentz@uark.edu.
*Contribution of the Arkansas Agricultural Experiment Station.
†Current address: North Carolina State University, Mountain Research Station, Waynesville 28786

wilting forages suffer losses of plant sugars and other water-soluble nutrients via leaching and/or prolonged or reactivated respiration by plant cells or microbes associated with the forage (Rotz and Muck, 1994). Cellular contents, including plant sugars, are assumed generally to be completely digestible by ruminants (Van Soest, 1982); therefore, the nutritive value of rain-damaged forages is reduced. In contrast, forages harvested as silage need only to be wilted to about 40% DM, which can be achieved relatively quickly. Therefore, the conservation of forages as silage can preserve plant nutrients and partially avoid dependence on good drying weather.

Historically, precision-chopped forages have been fermented and stored 1) in piles on the ground covered with dirt or plastic, 2) in horizontal trench or bunker silos, 3) in plastic bags or tubes ranging up to 150 m in length, and 4) in upright silos made of wood, metal, or concrete. Regardless of methodology, a key goal is to reduce respiration by plant cells during filling, and aerobic microbial activity at all points throughout filling, storage, or feed-out (Muck et al., 2003). Indicators of aerobic deterioration that are observed commonly include mold development, spontaneous heating, DM loss, increased concentrations of fiber components, and reduced nutrient digestibilities (Bolsen, 1995). At feed-out, aerobic deterioration becomes a critical concern because unlimited oxygen is available to support microbial respiration in all exposed silage. This type of spontaneous heating is dependent on several factors: 1) numbers of aerobic microorganisms in the silage 2) time exposed to oxygen prior to feeding, 3) silage fermentation characteristics, and 4) ambient temperature (Bolsen, 1995).

Recently, an alternative methodology has been developed that allows producers to bale long-stem forages in round bale form and then wrap these bales in a plastic stretch film. This form of storage, often called balage, has become very common in Arkansas and throughout the Upper South, largely because the same equipment can be used for both balage and conventional dry hay. Balage is often stored in long continuous rows of bales that are wrapped in plastic with an automated in-line bale wrapper. This is very convenient and efficient at harvest, but leads to potential problems at feeding because once a long row of balage is opened, oxygen has access to the exposed silage. Aerobic deterioration then can occur if the balage is not fed quickly. Potentially, this can be an even greater problem if the balage is to be sold as a cash crop, because large numbers of bales are exposed simultaneously and then transported prior to feeding. For buyers with a very limited number of animals to feed, exposure times of several weeks following delivery are easily possible. Producers interested in marketing balage as a cash crop often inquire whether balage will remain stable during loading, transport, and subsequent feeding operations at the buyer's facility. The aerobic stability of exposed balage during the winter months, when most of this product is fed or sold, remains unclear. Our objectives were to assess the aerobic stability of orchardgrass and wheat balage exposed to air during December and January in Fayetteville, Arkansas.

MATERIALS AND METHODS

Forages, Ensiling, and Storage

On May 6 and 7, 2002, 'Benchmark' orchardgrass and an unstated cultivar of soft-red winter wheat were harvested with a mower conditioner (Model 1411; Ford New Holland, Inc., New Holland, PA) and allowed to wilt to appropriate DM concentrations for ensiling as balage, which were measured as 54.4 and 62.4% DM, respectively, at the time plastic was removed from the bales. The orchardgrass was harvested at the heading stage of growth, and the wheat was harvested when the seed was at milk stage. Forages were raked into windrows with a New Holland Model 258 side-delivery rake and packaged immediately into 1.2- ×1.2-m round bales (Model XL604; Vermeer Manufacturing Co., Pella, IA). Bales were removed from the field and wrapped with 6 layers of 0.025-mm thick plastic film (Sunfilm; AEP Industries, Inc., Mt. Top, PA) on an in-line bale wrapper (Reeves Manufacturing Ltd., Miscouche, PE, Canada). The bales were positioned in continuous rows on a concrete pad with each row containing only one forage type. Bales remained there, undisturbed, until December 10, 2002; during this time interval, the plastic wrap surrounding the bales was checked regularly for any holes or tears and any potential entry points for air were patched immediately with tape that was resistant to ultraviolet light.

Initial Bale Evaluation

On December 10, 2002, the plastic wrap covering each row of at least 23 bales of wheat or orchardgrass balage was cut and removed completely from all bales. The bales at the end of each row were discarded, leaving a total of 21 internal bales of each forage type within each row. At exposure (d 0), bales were removed from the concrete pad, weighed, and placed on individual wooden pallets in an open-air pole barn. This method of stacking allowed for air space between bales and ensured equal air exposure across all bales to be evaluated. Bales were not moved with a hay spike; instead, a hydraulic grasping attachment (Model BH100; Vermeer Manufacturing Co.) was used that did not create