

Feeding Characteristics of Round-Bale Silages

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Despite some production issues associated with preservation of forages as round-bale silage, potential benefits with respect to minimizing DM loss and preserving forage quality compared with traditional hay preservation systems are well documented. Less information is available regarding the feeding value of forages preserved in this manner. This paper attempts to address issues associated with the utilization of round-bale silage by its ultimate consumer, the ruminant animal. Primary emphasis is placed on utilization of energy and protein because the compositional differences between forages preserved in different manners predominantly affect animal performance by altering the nature of these two components.

Potential Concerns

There are some potential nutritional concerns when dealing with round bale silage that are not generally applicable to hay feeding. Most of these are associated with failure to achieve a rapid fermentation. Because of potential variation in forage maturity, DM and water-soluble carbohydrate content, chop length, packing density, wrapping efficiency, and many other factors, the quality of fermentation in round bale silage production is quite variable. In situations in which low pH and/or anaerobic conditions are not achieved, a variety of potential animal health concerns can arise. Growth of molds and fungi can result in abortion, as can growth of *Bacillus* species, all of which are facilitated by aerobic conditions in poorly-preserved silage (Sargison, 1993). Similarly, high pH and presence of oxygen can allow the multiplication of *Listeria monocytogenes*, responsible for several clinical diseases in cattle, sheep, and horses (Sargison, 1993). Additionally round bale silage has been implicated in some cases of bovine and equine botulism. Although *Clostridium botulinum* is an obligate anaerobe, its growth is suppressed at lower pH values (Sargison, 1993).

Energy Consumption

The ability to support a given level of animal production from round bale silage will predominantly be a function of the quantity of energy the animal derives from the silage. In turn, this energy supply is primarily dependant on two factors: voluntary intake and digestibility. Voluntary forage intake is a complex phenomenon, affected by numerous factors. Primary factors to consider when evaluating fermented feeds include fiber concentrations, particle size, as it relates to passage rate, and potential intake inhibitors such as high levels of $\text{NH}_3\text{-N}$ or butyric acid.

Voluntary Intake

Relatively few studies have compared the voluntary intake of forage preserved as hay compared with round bale silage. McCormick et al. (1998) reported similar DM intakes by lactating Holstein cows for ryegrass preserved as hay compared with round bale silage. However, theirs was a systems analysis: consequently, forages were

harvested at the boot stage for silages and at the bloom stage for hay. These maturity differences and the ensuing differences in chemical composition resulted in greater amounts of grain feeding for cows consuming hay. Thus, the best comparison of the two systems in their study is afforded by their measure of feed efficiency (lb FCM/lb DMI), which was 12.5% greater for the round bale silage system. Interestingly, intake of chopped haylage reported by McCormick et al. (1998) was about 15% greater than for the other two systems, presumably as a consequence of the smaller particle size, as only minor differences were noted in the chemical composition of the two fermented forages. This suggests that opportunities may exist to increase voluntary intake of forage preserved as round bale silage. This rationale formed part of the basis for a study evaluating the effects of pre-ensiling maceration on utilization of orchardgrass/white clover silages (Charmley et al., 1999). However, in that study, voluntary intake of macerated round bale silage by growing steers was not different than intake of conventionally-conditioned round bale silage. This lack of difference could relate to differences in chemical composition of the two round bale silages, consequent to higher DM concentrations in the macerated silages. Despite the absence of intake effects, gain:feed ratios were improved by about 25% with maceration. In another study, Charmley and Firth (2004) compared intakes by cattle consuming round bale silage that was harvested in long form, or coarsely sliced with a cutting assembly attached to their round baler. Again, no difference was detected in voluntary intake, perhaps because they achieved only minor differences in mean particle length with this approach. Though evaluating conventional silages (preserved in stave silos) rather than round-bale silages, Petit et al. (1985) found no difference due to conservation method (silage vs. hay) in DM intake by steers for alfalfa, timothy, or mixed legume/grass forage. In that study, only minor differences were detected in the chemical composition of the forages due to conservation method. Recently, Han et al. (2004) reported greater voluntary DM intake by steers consuming alfalfa preserved as round bale silage as compared with alfalfa hay harvested from the same field. These differences in intake reflected the greater fiber and lower crude protein concentrations in the hay, which were attributed to greater respiratory and leaf shatter losses in the hay conservation system. In a report by Oshita et al. (2004), non-lactating Holstein cows ate about 15% more DM when consuming round bale alfalfa silage than when consuming long-stem alfalfa hay of similar chemical composition. However, the silage was chopped to a nominal length of 40 mm before being fed to the cows.

Other studies have compared voluntary intake of round bale silage with other, more conventional types of silage systems. Interestingly, Charmley and Firth (2004) reported greater intakes by steers consuming round bale timothy silage as compared with flail-harvested silage, despite smaller mean particle size for the latter system. They suggested that the greater degree of wilting for the round bale silages was the most likely explanation, and others (Gordon et al., 1999) have reported increasing voluntary intake with increasing baleage DM concentrations. Charmley and Firth (2004) found numerically, but not statistically greater voluntary intake by cattle consuming round bale vs. precision-chopped silages. Conversely, Petit et al. (1993) reported lower intakes of round-bale grass silage compared with silage harvested with either a cylinder-type or self-loading forage harvester. In that study, the DM concentration was greatest with the round bale silage, as was the ultimate silage pH. Likewise, Nicholson et al. (1991) found

poorer fermentation in bale-, as compared with chopped, bagged alfalfa silage (higher pH, lower lactic acid in bales) coupled with lower voluntary intakes.

Taken together, the above reports suggest that, if hay and silage are both well-preserved and of similar chemical composition and particle size, little difference would be expected in voluntary intake. However, improvements in maintenance of forage quality with baled silage systems relative to hay systems would be expected to translate into parallel improvements in voluntary DM intake. Effects of various silage systems on voluntary intake are largely mediated through effects on the quality of fermentation achieved. Variability in achieving rapid acidification in round bale silage is likely a primary cause for the variability in intake responses in the literature. Furthermore, potential may exist to enhance voluntary intake of round bale silage through pre- or post-ensiling processing to reduce particle size.

Digestibility

Although digestibility measures account for only a fraction of the dietary energy lost by animals, this fraction represents the major source of variation in energy utilization when comparing forage conservation systems. Although changes in silage fermentation characteristics will manifest as changes in ruminal fermentation characteristics, it is unlikely that such shifts will typically have a major influence on the utilization of energy. In support of this argument, calorimetric studies with growing steers (Gordon et al., 1999) have shown that, even when comparing fermentation stimulants with fermentation inhibitors or wilted (45% DM) with unwilted (19% DM) silages, the major differences in energy utilization were accounted for by changes in digestibility, as opposed to changes in urinary energy, methane energy, or efficiency of ME use.

Oshita et al. (2004) were able to produce alfalfa round bale silage very similar in chemical composition to a commercially-procured alfalfa hay. Although DM digestibility was not significantly affected by preservation method, digestibilities of NDF, ADF, and cellulose were all greater with the ensiled product. As with their intake responses, Petit et al. (1985) found no differences in digestibilities when comparing hay- and conventional silage-preservation systems for three different forage types. Han et al. (2004) had greater DM digestibility with round bale alfalfa silage than for alfalfa hay. The lower digestibility for the hay in that study was likely a consequence of the greater fiber concentrations in the hay, due to pre-storage DM loss through leaf shatter and respiration. Petit et al. (1993) reported a trend toward greater digestibility of gross energy for round bale silage compared with conventionally stored silage harvested by either of two approaches. However, this trend occurred in the presence of lower voluntary intake, confounding our interpretation. In the study by Charmley and Firth (2004), digestibilities were nearly 8 percentage units greater for round bale silage than for either flail-harvested or precision-chopped silage, even in the presence of greater intakes for the round-bale silage treatment.

Thus, digestibility values, like intake values, are ultimately driven by the ability of a given conservation system to maintain high forage quality. However, because of the negative effect of increasing intake on digestibility, the apparent digestibilities measured in vivo can exhibit the opposite trend of what one may expect based strictly on chemical composition. In such cases, use of in situ measures of degradation can help separate

inherent differences in digestibility from different preservation methods from effects of intake, per se. For example, in the studies by Charmley et al. (1999), intakes of macerated round bale silage were substantially greater than intakes of macerated, precision-chopped silage. Digestibilities of all measured components were considerably less for the macerated, round bale silage. In situ DM disappearance data from this study showed that there were no inherent differences in the degradation rates or effective degradation values as a result of the different preservation systems, leading to the conclusion that the differences in digestibility were strictly a function of intake differences. Petit and Tremblay (1992) found a much larger fraction of DM in the potentially degradable pool ('A' + 'B' fractions) and, consequently, a substantially greater effective DM degradability for grass conserved as silage (round bale or heap silage) as compared with hay. This increase in effective degradability was observed despite a 50% average decrease in the measured degradation rate of the potentially degradable DM fraction with the silages.

Protein Characteristics

The primary differences in the nitrogenous fractions between forage conserved in round bale silage vs. hay systems are shifts in the overall concentration of crude protein and shifts in the composition of the N fractions, particularly through proteolysis and deamination. In situations in which excessive heating occurs (in either hay or silages), protein availability can decrease through formation of Maillard reaction products. Though silage conservation methods will typically allow us to retain higher crude protein concentrations relative to hay, a larger portion of the crude protein will be in the form of NPN, ultimately increasing the degradable protein fraction. In situ protein degradation data from Petit and Tremblay (1992) can be used to highlight the importance of such changes. Using the NRC (1996) Level I Model and estimates of DM and CP disappearance from the in situ analysis of Petit and Tremblay (1992), one can generate estimates of energy and metabolizable protein-limited gains. Using the nutrient requirements for a 272 kg growing steer consuming forage at 2.4% of body weight, and effective degradability estimates generated by Petit and Tremblay (1992) for a $2\% \cdot h^{-1}$ passage rate, their hay, containing 19.5% CP would be predicted to provide sufficient metabolizable protein to support 0.86 kg/d gain, yet only enough energy to support a gain of 0.68 kg/d. Conversely, because of the high degree of degradable protein in the round bale silage, consumption of an equivalent amount of this forage would be predicted to have sufficient energy to support a gain of 1.12 kg/d, yet would supply enough metabolizable protein for only 0.62 kg/d gain. Thus, switching from hay to round bale silage in this instance, with the exclusion of any supplements, would be anticipated to result in lower gains, despite the increase in available energy. In such cases, animals would be expected to respond to dietary supplementation with undegraded protein sources. Such a response was documented by Rouzbehan et al. (1996) when growing steers, consuming grass/clover round bale silage were supplemented with fish meal. Quantitative knowledge of ruminal protein degradation characteristics is essential for calculation of proper diets to optimize growth, especially for animals consuming diets high in degradable protein.

Effects of Additives

Generally, researchers evaluating use of additives for round bale silage have reported some benefits, particularly for retarding growth of mold and yeasts. However, there seems to be some consensus that potential effects of additives are minor in comparison to potential effects of factors such as DM content, forage species, maturity, and wrapping strategy (Bates et al., 1989; Keller et al., 1998). Chaudhry et al. (2001) improved the storage quality and voluntary intake of round bale silage prepared from mature Rhodes grass hay through the use of pre-ensiling NaOH treatment. No benefits were observed from using NaOH on young grass silage, nor were benefits seen from CaO treatment or treatment with inoculant derived from ruminal microorganisms from Rhodes grass-fed cattle. With round bale silages prepared from forage pea or field bean forages (Fraser et al., 2001), inoculation with *L. plantarum* improved lactic acid concentrations and decreased pH, NH₃-N, and acetic acid concentrations in the silages. However, the authors also noted decreased N retention in growing lambs in response to inoculation. These results suggest that inoculation may have resulted in some increase in proteolysis without concomitant deamination, as NH₃-N concentrations were lower with inoculation. Nowak et al. (2004) failed to detect any effects of *L. plantarum*/*E. faecium* inoculants on ruminal or small intestinal protein disappearance of perennial ryegrass round bale silage. However, they also failed to elicit significant effects on the chemical composition or fermentation characteristics of the silage. In a summarization of twenty-two experiments with round bale grass silage Haigh et al. (1996) found that use of inoculants significantly increased lactic acid and decreased butyric acid concentrations. However, little benefit was seen in silage DM intake or live weight gain when the silages were fed to growing lambs. Alternatively, Meeske et al. (2002) reported minor effects on fermentation characteristics of round bale oat silage in response to inoculation with *L. plantarum*/*S. faecium*/*P. acidilactici*, yet found increased silage intake and milk production of lactating Jersey cows consuming the silages. Because of this apparent disconnect between silage fermentation characteristics and animal responses, evaluation of potential benefits of round bale silage additives should incorporate animal feeding studies whenever possible.

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