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Silage review: Silage feeding management: Silage characteristics and dairy cow feeding behavior[1]

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ABSTRACT

Feeding environment and feed accessibility influence the dairy cow's response to the ration and forage composition. Fiber content, physical form, and fermentability influence feeding behavior, feed intake, and overall cow metabolic and lactational responses to forage. It is possible to vary eating time of lactating dairy cattle by over 1 h/d by changing dietary silage fiber content, digestibility, and particle size. Optimizing silage particle size is important because excessively long particles increase the necessary chewing to swallow a bolus of feed, thereby increasing eating time. Under competitive feeding situations, excessively coarse or lower fiber digestibility silages may limit DMI of lactating dairy cows due to eating time requirements that exceed available time at the feed bunk. Additionally, greater silage particle size, especially the particles retained on the 19-mm sieve using the Penn State Particle Separator, are most likely to be sorted. Silage starch content and fermentability may influence ruminal propionate production and thereby exert substantial control over meal patterns and feed consumption. Compared with silage fiber characteristics, relatively little research has assessed how silage starch content and fermentability interact with the feeding environment to influence dairy cow feeding behavior. Finally, voluminous literature exists on the potential effects that silage fermentation end products have on feeding behavior and feed intake. However, the specific mechanisms of how these end products influence behavior and intake are poorly understood in some cases. The compounds shown to have the greatest effect on feeding behavior are lactate, acetate, propionate, butyrate, ammonia-N, and amines. Any limitation in the feeding environment will likely accentuate the negative response to poor silage fermentation. In the future, to optimize feeding behavior and dry matter intake of silage-based diets fed to dairy cattle, we will need to consider the chemical and physical properties of silage, end products of silage fermentation, and the social and physical components of the feeding environment.
Key words: silage, fermentability, feeding behavior, feed intake

INTRODUCTION

Forages fed as silage remain popular for dairy farms because they minimize loss of nutrients from harvest through storage, allow for easier feeding, and often allow greater efficiency and timeliness of feed mixing and handling on the farm than dry forages (Mahanna and Chase, 2003). Measuring the chemical composition and physical properties of silages is important for proper ration formulation and troubleshooting silage quality problems; voluminous literature exists on this topic (e.g., Kung and Shaver, 2001; Heinrichs and Kononoff, 2013). The content and fermentability of silage fiber, starch, and protein, together with fermentation end products, influence dairy cattle feeding behavior and DMI (Oliveira et al., 2017).

The physical and social environment in which the forage is fed will also have a modulating effect on the feeding and productive response by the cow (Grant and Albright, 2001). For example, Bach et al. (2008) reported on the nondietary factors that most influenced milk production among dairy farms that fed the same TMR containing corn and triticale silages. In their study, 2 of the most important factors explaining variation in milk yield among farms were routine feed push-up and feeding for TMR refusal at the end of the daily feeding cycle. Ensuring access to the feed was associated with 1.6 to 3.9 kg/d greater milk production per cow. The results of the Bach et al. (2008) study illustrate the importance of optimizing the feeding environment and feed bunk management such that the cow will respond most productively to the nutritional value of the silage in the ration.

How silage quality interacts with feed bunk management needs to be understood to optimize the cow's

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behavioral and productive response to the silage. The objectives of our paper are to review (1) how silages of varying fiber content, digestibility, and particle size; starch content and digestibility; and fermentation end product profile influence dairy cattle feeding behavior and DMI, and (2) how the feeding environment may modulate the animal's feeding behavior and DMI response to silages of varying nutritional value.

SILAGE FIBER CHARACTERISTICS, FEEDING BEHAVIOR, AND DMI

Dietary NDF content, digestibility, and particle size influence fiber intake, chewing behavior, ruminal turnover, and efficiency of milk production (Oba and Allen, 2000). As ration fiber content increases, cows will typically spend more time eating, have longer meal length, and practice greater sorting behavior (Beauchemin, 1991). In contrast, as NDF digestibility increases, chewing time per unit of NDF often decreases (Beauchemin, 1991).

The chewing index, expressed as minutes of chewing elicited per kilogram of DM, typically decreases as forage NDF digestibility increases, particle length is shortened, or NDF content decreases. A negative linear relationship exists between DMI and the dietary chewing index for silage-based diets primarily composed of grass and grass-clover silages, alfalfa silage, corn silage, and whole-crop silages (Jensen et al., 2016). Although not reflected in the chewing index, part of the potentially negative effect of some silages on energy intake is related to low silage DM content and the negative effects of higher silage fermentation end products (Huhtanen et al., 2007). Nonetheless, it is clear that silage NDF content, digestibility, and particle size significantly influence chewing activity and DMI in ruminants (Oba and Allen, 2000).

Dietary Forage Content, Fiber Digestibility, and Particle Size

Jiang et al. (2017) observed a 1.8 h/d greater eating time when dietary forage content increased from 40 to 70% (mixture of corn silage, alfalfa hay, oat hay, and rye hay); but rumination time only increased by 35 min/d. Interestingly, resting time decreased by 2.3 h/d. Thus, greater time eating came primarily at the expense of resting and, in fact, the greater total chewing time (eating + rumination) as forage content increased was exactly offset by lost resting time (2.3 h/d). This interaction between eating and resting behavior is well documented and underscores the inelastic resting requirement of dairy cattle (Jensen et al., 2005; Munksgaard et al., 2005).

Miron et al. (2007) compared brown midrib sorghum silage, conventional sorghum silage, and conventional corn silage and found that in vitro DM digestibility was greater for the brown midrib sorghum and corn silage. The DMI per meal was greater for cows fed the higher-digestibility silage, but the number of daily meals was greater for cows fed the lower-digestibility silage. These results agree with Oba and Allen (2000), who observed lower DMI when cows were fed a greater-NDF diet and when the diets contained control rather than brown midrib corn silage. Taylor and Allen (2005) found that cows fed brown midrib corn silage spent 1.7 min/meal less than their cohorts fed conventional corn silage, although they had similar meal size. Overall, these studies indicate that forage with greater fiber digestibility is associated with feeding behavior and meal patterns that increase DMI.

Cotanch et al. (2012) fed diets that contained either lower (49 to 53% of ration DM) or higher silage content (64 to 67% of ration DM), and, within each forage level, either conventional or brown midrib corn silage was fed to vary the forage NDF digestibility. Eating time was 1 h greater for cows fed the higher-forage diet containing the conventional corn silage versus those cows consuming the lower-forage diet with brown midrib corn silage. Additionally, whether the cows consumed conventional or brown midrib silage was associated with a difference of 30 min/d in time spent eating. The increase in time spent eating with greater forage content and NDF digestibility was almost exactly offset by reduction in lying time, similar to Jiang et al. (2017), as they varied dietary forage content.

Kononoff and Heinrichs (2003) compared the effects of alfalfa silage that varied in geometric mean length from 4.1 to 6.8 mm and found that daily eating time increased by 36 min/d as silage particle size increased. At the same time, DMI decreased by 3.3 kg/d, indicating that it took the cows longer to consume less DM of more coarsely chopped silage. Similarly, Fernandez and Michalet-Doreau (2002) compared corn silage chopped to either 4.2 or 12.0 mm theoretical length of cut and observed that time spent eating was reduced by 43 min/d for cows fed the finer chopped silage despite similar DMI.

Fernandez et al. (2004) compared the effects of 2 corn silage hybrids varying in NDF digestibility either when finely or coarsely chopped (5 vs. 13 mm theoretical length of cut, respectively). Regardless of chop length, the hybrid with greater NDF digestibility elicited greater DMI with similar eating, rumination, and chewing times. Bal et al. (2000) compared unprocessed corn silage harvested at 9.5 mm theoretical length of cut with processed corn silage harvested at 9.5, 14.5, or 19.0 mm theoretical length of cut using a conventional