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Corn Grain Endosperm Type and Brown Midrib 3 Corn Silage: Feeding Behavior and Milk Yield of Lactating Cows

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ABSTRACT

Interactions of endosperm type of corn grain and the brown midrib 3 mutation (*bm3*) in corn silage on feeding behavior, productivity, energy balance, and plasma metabolites of lactating dairy cows were evaluated. Eight ruminally and duodenally cannulated cows (72 ± 8 d in milk; mean ± SD) were used in a duplicated 4 × 4 Latin square design experiment with a 2 × 2 factorial arrangement of treatments. Treatments were corn grain endosperm type (floury or vitreous), and corn silage type (*bm3* or isogenic control). Diets contained 26% neutral detergent fiber (NDF) and 30% starch. Floury endosperm grain decreased dry matter intake (DMI) 1.9 kg/d compared with vitreous grain when combined with control corn silage but did not affect DMI when combined with *bm3* corn silage. This interaction of treatments occurred because of changes in meal size; floury endosperm grain decreased meal size in control silage diets but increased meal size in *bm3* corn silage diets. Ruminal pool sizes reflected DMI differences among diets, suggesting that ruminal fill was not the primary limitation on intake. Brown midrib 3 corn silage reduced rumination time per day and number of rumination bouts per day. Floury endosperm grain decreased 3.5% fat-corrected milk by 1.2 kg/d when combined with control silage but increased 3.5% fat-corrected milk by 2.1 kg/d when combined with *bm3* corn silage. Starch and fiber digestibility interact to affect feeding behavior and milk production and production response to *bm3* corn silage depends on the grain source that is fed.
(**Key words:** endosperm, brown midrib, feeding behavior)

Abbreviation key: ***bm3*** = brown midrib 3 mutation, **iNDF** = indigestible NDF, $\mathbf{NE_M}$ = net energy for maintenance, **pdNDF** = potentially digestible NDF.

INTRODUCTION

Energy intake often limits milk yield for high-producing dairy cattle, and strategies to maximize energy intake are critical to maximize production. Although diets are often formulated based on nutrient concentration alone, an analysis of the literature indicated that forage NDF digestibility measured in vitro or in situ was positively related to feed intake and milk yield; a mean increase in NDF digestibility of 8.4 units across forage comparisons was associated with a 1.4-kg/d greater DMI, resulting in a 2.1-kg/d greater 4% FCM yield (Oba and Allen, 1999). The brown midrib mutation decreases lignin content and increases in vitro NDF digestibility of forages (Cherney et al., 1991). Feeding brown midrib sorghum (Grant et al., 1995) and corn (Oba and Allen, 2000a) silages have improved DMI and milk production in dairy cows; increases in DMI are a result of changes in meal patterns (Oba and Allen, 2000a). Brown midrib corn silage can affect DMI by changing meal patterns but how brown midrib corn silage interacts with other dietary components to affect feeding behavior is unknown.

Variation in starch digestibility is often not considered in diet formulation but ruminal starch digestibility for a variety of feedstuffs ranged from 42 to 96% (Nocek and Tamminga, 1991). Starch digestibility is dependent on several factors, including grain type, processing methods, and physical characteristics of the grain. Starch granules in vitreous or flinty endosperm are surrounded by an insoluble protein matrix that resists digestion; in contrast, floury or opaque endosperm has a soluble protein matrix that is easily digested by ruminal microorganisms (Kotarski et al., 1992). Grain vitreousness is dependent on both hybrid and maturity (Philippeau and Michalet-Doreau, 1997) and is negatively correlated with in situ ruminal starch disappearance across hybrids (Philippeau et al., 1999a). Flint endosperm decreased ruminal starch digestibility 26 percentage units (34.8 vs. 60.8, $P < 0.001$) compared with a dent genotype when fed to steers (Philippeau et al., 1999b).

Increased ruminal starch degradability has significantly depressed DMI in some experiments but not others (Allen, 2000). Feed intake is a function of both meal size and meal frequency, determined by satiety and hunger, respectively, so meal patterns are likely influenced by ruminal starch digestion. Diets high in rumi-

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nally degraded starch decreased DMI by decreasing meal size (Oba and Allen, 2003a), and linear addition of refined cornstarch to the diet linearly decreased meal length but tended to increase the number of meals consumed in a day (Krause et al., 2003). Because endosperm type can dramatically change ruminal starch digestibility, research is needed to specifically examine the effect of corn endosperm type on feeding behavior of lactating dairy cows.

Although meal patterns and DMI are affected by changes in ruminal starch and fiber digestibility, potential interactions between varying digestibility of fiber source and endosperm type of corn grain on intake and production of dairy cows have not been investigated. We hypothesized that highly fermentable grain with floury endosperm would have greater effect at reducing meal size and possibly DMI when combined with brown midrib 3 (***bm3***) corn silage than control silage. The objective of this experiment was to evaluate effects of the *bm3* mutation in corn silage and corn grain endosperm type on feeding behavior, DMI, milk yield, and energy balance of lactating dairy cows.

MATERIALS AND METHODS

This article is the second of 3 articles in a series from one experiment that evaluated effects of corn grain endosperm type and the *bm3* mutation in corn silage. This article discusses treatment effects on feeding behavior and milk production, and the companion articles focus on ruminal fermentation and microbial N efficiency (Taylor and Allen, 2005a) and site of digestion and ruminal kinetics (Taylor and Allen, 2005b). Experimental procedures were approved by the All University Committee on Animal Use and Care at Michigan State University.

Cows and Treatments

Eight multiparous Holstein cows (72 ± 8 DIM; mean ± SD) from the Michigan State University Dairy Cattle Teaching and Research Center were assigned randomly to treatment sequence within duplicate 4 × 4 Latin squares balanced for carryover effects. A 2 × 2 factorial arrangement of treatments was used with main effects of corn grain endosperm type (floury or vitreous) and *bm3* mutation in corn silage (present or absent). Treatment periods were 21 d, consisting of an 11-d diet adaptation period followed by 10 d of collection. Surgical preparation of ruminally and duodenally cannulated cows is reported in Taylor and Allen (2005b). At the beginning of the experiment, empty body weight (ruminal digesta removed) of cows was 531.8 ± 43.9 kg (mean ± SD).

Two corn hybrids, 6208FQ and 657 (Cargill Hybrid Seeds, Minneapolis, MN), were planted for silage in the spring of 2001 at the Michigan State University Research Farm. The hybrids are isogenic except that Cargill 657 contains the *bm3* mutation. Harvesting conditions of both silages were reported previously (Taylor and Allen, 2005b). Nutrient compositions and physical characteristics of treatment corn silages used in the experiment are reported in Table 1 of Taylor and Allen (2005b).

Two corn hybrids varying in endosperm type (floury and vitreous) were planted for grain in the spring of 2001 at the Michigan State University Research Farm. The floury (SL53; Crow's Hybrid Corn Company, Kentland, IN) and vitreous (Z75W; Wilson Genetics, Harlan, IA) hybrids were selected based on their high and low in vitro starch digestibility, respectively. Harvesting conditions of both corn grains were reported previously (Taylor and Allen, 2005b). Vitreousness (% of endosperm) for floury and vitreous corn grain was 3.0 and 67.2%, respectively (Taylor and Allen, 2005b). Nutrient compositions and physical characteristics of the corn grain treatments used in the experiment are shown in Table 2 of Taylor and Allen (2005b).

Experimental diets contained dry ground corn treatments (floury or vitreous), corn silage (*bm3* or isogenic normal), alfalfa silage (10% of diet DM), whole linted cottonseed (7% of diet DM), a protein supplement premix (soybean meal, distillers grains, and blood meal), and a premix of minerals and vitamins. Experimental diets were fed as TMR and were formulated to contain 27% NDF, 18% CP, and minerals and vitamins to meet requirements according to NRC (2001). Ingredient and nutrient compositions of the experimental diets are reported in Table 3 of Taylor and Allen (2005b).

Data and Sample Collection

Cows were housed and fed as described previously (Taylor and Allen, 2005b). Cows were milked twice daily in their stalls during the feeding behavior monitoring phase (d 15 to 18) and in a milking parlor during the remainder of each period. Milk yield was measured and milk was sampled at each milking on d 15 to 18. Empty body weight was measured after evacuation of ruminal digesta on the day immediately before the start of the first period and on d 21 of each period. Body condition score was determined on the same day by 3 trained investigators blinded to treatments (Wildman et al., 1982; 5-point scale where 1 = thin and 5 = fat).

Feeding behavior was monitored from d 15 through d 18 (96 h) of each period by a computerized data acquisition system (Dado and Allen, 1993). Data of chewing activities, feed disappearance, and water consumption