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Influence of inoculating forage with lactic acid bacterial strains that produce ferulate esterase on ensilage and ruminal degradation of fiber☆

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Abstract

By releasing ferulic acid from cell wall arabinoxylans, ferulate esterase (FE) can increase susceptibility of plant cell walls to enzymatic hydrolysis. As some lactic acid bacteria (LAB) produce FE, we investigated effects of ensiling perennial ryegrass (PRG) with LAB that produce FE on ruminal NDF degradation (NDFD) of the resulting silages. Among the 10,000 LAB screened, approximately 500 produced FE and 8 (*i.e.*, *Lactobacillus buchneri* PTA-6138 and NRRL B-30866; *Lactobacillus crispatus* NRRL B-30868, 30869 and 30870; *Lactobacillus reuteri* NRRL B-30867; *Lactobacillus brevis* NRRL B-30865 and an unidentified *Lactobacillus* NRRLB-30871) were studied in detail. The PRG was harvested and ensiled with or without (control) inoculation with each individual LAB, in triplicate laboratory silos for 30 days. Silages were analyzed for fermentation characteristics, dried, ground (6 mm) and incubated *in situ* in Dacron bags (50 μm pore size) for 48 h in the rumens of three ruminally cannulated steers adapted to a diet of grass silage. *L. buchneri* strains increased silage pH

Abbreviations: ADF, acid detergent fiber; ADFD, ADF degradation; cfu, colony forming units; DM, dry matter; FE, ferulate esterase; FFW, forage fresh weight; LAB, lactic acid bacteria; MRS, De Man Rogosa Sharpe; aNDF, neutral detergent fiber; NDFD, NDF degradation; pNP, *P*-nitrophenyl; PRG, perennial ryegrass; ROT, rise over temperature; VFA, volatile fatty acids; WPCF, whole plant corn forage; WPCS, whole plant corn silage.

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and acetate (P<0.05) and reduced lactate concentrations (P<0.05). With the exception of NRRLB-30871, all LAB increased (P<0.05) NDFD by 9–11%. To examine effects of combining *L. buchneri* PTA-6138 with *Lactobacillus paracasei tolerans* PTA-6135 (X11C38) on NDFD of whole plant corn silage (WPCS), forage (DM, 337 g/kg) was harvested and ensiled with or without inoculation in two silos of 2 tonnes each and allowed to ferment for 180 days. Fresh silage from each silo was fed to three ruminally cannulated steers in a cross-over experiment with two periods of 14 days that included 10 days for adaptation. WPCS was incubated *in situ*, as described above, in all six steers in a split–plot experiment with diet as the main plot and inoculation of silage as the subplot. Feeding inoculated silage did not influence NDFD and there was no interaction between the silage fed and inoculation of the silage incubated *in situ*. However, inoculation of forage with X11C38 increased NDFD by 15.8% (P=0.019). Since *L. buchneri* can improve aerobic stability (AS) of silage, we also determined effects of X11C38 on AS of WPCS. Forage from four hybrids was harvested, and each ensiled with or without inoculation in four laboratory silos that were stored for 50–57 days. AS was determined by recording silage temperature with oxygen exposure in a thermostable environment. Inoculation with X11C38 extended the duration of AS for all hybrids by 42–105 h (P<0.05). Inoculation with LAB that produce FE improve NDFD in ensiled PRG and X11C38 extended AS and improved NDFD of WPCS, suggesting that higher NDFD was due to changes in forage during storage.

Keywords: Ferulate esterase; NDFD; *Lactobacillus buchneri*

1. Introduction

Ensiling is the anaerobic process of preserving moist crops by lactic acid fermentation. Under optimal ensiling conditions, epiphytic lactic acid bacteria (LAB) predominantly ferment endogenous plant water soluble carbohydrates into lactic acid that acidifies the crop and minimizes activity of aerobic organisms to preserve forage nutrients (McDonald et al., 1991).

Effective traditional silage inoculants can accelerate or enhance lactic acid fermentation and improve preservation of forage because epiphytic LAB are often insufficient for efficient lactate fermentation (McDonald et al., 1991). Treatment of forage at ensiling with an effective bacterial inoculant under favourable ensiling conditions often improves animal performance, but these effects are typically attributed to improvements in fermentation (Muck, 1993). However, Keady and Steen (1995) observed that inoculating grass at ensiling with a commercial silage inoculant consisting of a single strain of *Lactobacillus plantarum* improved performance of beef cattle fed a ration containing the silage, in spite of there being no apparent change in silage fermentation characteristics. Indeed, these researchers were unable to relate any characteristic of the bacterial inoculant to the improved animal performance. More recently, LAB inoculants have been shown to survive ruminal conditions (Weinberg et al., 2003) and that LAB are consumed with silage to enter the rumen (Weinberg et al., 2004). Hence, feeding inoculated silage to ruminants can deliver direct-fed microorganisms to potentially enhance rumen function. Because of the possibility that LAB silage inoculants do more than preserve forage nutrients, efforts are underway to discover novel LAB strains with specific animal nutrition-enhancing properties that can be used as silage inoculants (Weinberg et al., 2004).