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Effects of chop-length and a ferulic acid esterase-producing inoculant on fermentation and aerobic stability of barley silage, and growth performance of finishing feedlot steers

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ABSTRACT

The present study investigated the impact of forage chop length and a ferulic acid esterase producing (FAE) inoculant on fermentation, aerobic stability and the physically effective fibre value of barley silage for finishing feedlot cattle. Whole-crop barley (*Hordeum vulgare* L.; 310 g DM/kg) was chopped to either a short (10.0 mm; SC) or long (20.0 mm; LC) chop length and ensiled with or without a FAE inoculant containing *Lactobacillus buchneri* LN4017, *Lactobacillus plantarum* LP7109 and *Lactobacillus casei* LC3200 in Ag-Bags® or mini silos. Data were analyzed as a 2 × 2 factorial using the MIXED procedure of SAS. In mini silos, the terminal pH of inoculated silage was lower (P=0.001) for SC than LC silage (3.87 vs 4.02). In mini silos, inoculation failed to increase acetic acid concentration of SC silage, but it increased acetic acid content of LC silage (P=0.034) and of both SC (45.7 vs 24.3 g DM/kg) and LC (54.3 vs 15.9 g DM/kg) in Ag-Bags®. In mini silos, lactic acid concentration was greater (P=0.011) in LC than SC (81.5 vs 67.3 g DM/kg) and inoculation decreased (P=0.020) the lactic:acetic acid in LC, but not SC silage. Populations of lactic acid bacteria were greater (P=0.002) and yeast lower (P=0.030) for inoculated silages stored in mini silos. Neither chop length, inoculation nor their interaction affected (P≥0.186) silage DM loss. Both inoculated and uninoculated SC silage remained stable over 8 d of aerobic exposure, but inoculation prolonged the aerobic stability of LC silage by 5 d (d 3–8). Growth performance and DM intake of finishing steers were not affected (P≥0.257) by chop length, inoculation or their interaction, but the proportion of saleable meat and the rib eye area of carcasses was greater (P=0.017; P=0.035 respectively) for steers fed SC than for those fed LC silage. Increasing the chop length of barley silage increased its physically effective fibre content, and the inoculant improved the aerobic stability of LC silage. However, likely owing to the low proportion of silage in the diet (100 g/kg, DM basis), neither chop length nor inoculation altered the growth performance of finishing feedlot cattle.

Abbreviations: ADG, average daily gain; ADF, acid detergent fibre; CFU, colony-forming units; DM, dry matter; DMI, dry matter intake; aNDF, neutral detergent fibre expressed inclusive of residual ash; FAE, ferulic acid esterase; LAB, lactic acid bacteria; LC, long chop; MRS, de Man–Rogosa–Sharpe agar; SC, short chop; SDA, Sabouraud's dextrose agar; TMR, total mixed ration; WSC, water-soluble carbohydrates; VFA, volatile fatty acids.

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1. Introduction

Forage is included in finishing feedlot diets to provide "physically effective" fibre and a longer chop length is one approach to increasing the physically effective fibre content of the diet. However, a longer chop length may impede compaction and oxygen removal from the silage during packing, delaying the transition to anaerobiosis, slowing the rate of acidification and negatively affecting silage quality. A longer chop length may also increase DM loss during feed-out by enhancing the ingress of air into the silage and its susceptibility to aerobic deterioration (Savoie et al., 1992; Ruppel et al., 1995). Barley silage is the principal dietary forage used by the feedlot industry in Western Canada. It is usually chopped to ~10.0 mm prior to being ensiled (Mills and Kung, 2002; Addah et al., 2012a,b). Effects of chop length on the fermentation process should be minimal when chop length is ~20 mm or less (Hara and Tanigawa, 2010) or when silages are packed to the same density (Marsh, 1978), but effects of chop length on aerobic stability of barley silage has not been studied.

Even though a shorter chop length may increase digestibility of fibre in forage diets (Soita et al., 2002), in high concentrate diets, silage with a shorter chop length contains less physically effective fibre. In finishing feedlot diets, grain accounts for the majority of the diet and forages normally comprise less than 10% of the diet DM. Shortening the chop length of silage can reduce rumination and the production of saliva, potentially increasing the risk of acute or sub-acute ruminal acidosis in cattle fed finishing grain diets.

In contrast, a longer chop length can contribute to rumen fill and a reduction in dry matter intake (DMI). Reducing the chop length of barley silage from 18.8 mm to 4.7 mm increased DMI of steers fed silage-only diets by 18% (Soita et al., 2002). In contrast, DMI of dairy cows was not altered by chop length of corn silage if it only comprised 460 g DM/kg of the diet (Yang and Beauchemin, 2006). Similarly, within a range of 0.6–3.8 mm for grass silage, Savoie et al. (1992) also found no consistent effect of chop length on silage quality, DMI or milk production of dairy cattle when silage constituted 560 g DM/kg of the diet. Although the impact of changes in chop length on ruminant production have been inconsistent, it is clear that increasing the chop length of silage reduces fuel consumption during chopping, lowering harvesting costs and time (Tremblay et al., 1990), as well as the emission of greenhouse gases from the combustion of fossil fuels.

Treatment of forages with an exogenous fungal ferulic acid esterase (FAE) hydrolyzed feroulylated polysaccharides and released sugars (Krueger et al., 2008). In an earlier study, the inoculation of whole-crop barley silage chopped at 9.5 mm with a FAE-producing bacterial inoculant resulted in favourable shifts in silage fermentation, improved silage digestibility (Addah et al., 2012b) and the growth efficiency of feedlot cattle fed high barley silage (~760 g/kg) diets (Addah et al., 2012a). The application of an FAE-producing inoculant on barley silage chopped to a longer chop length in finishing feedlot diets could prove desirable, potentially reducing the risk of acidosis, enhancing ensiling and aerobic stability while possibly improving silage digestibility and animal performance.

This study determined whether increasing the chop length of barley silage at harvest from 10.0 mm to 20.0 mm and inoculation with a FAE-producing inoculant improves silage quality and its utilization by finishing feedlot steers.

2. Materials and methods

2.1. Silage preparation and sampling

Whole-crop barley (*Hordeum vulgare* L.) from a single field was harvested at the mid-dough stage of kernel maturity (220–350 g DM/kg) on August 23, 2010 and chopped at either 10.0 mm (short; SC) or 20.0 mm (long; LC) on a single day using two John Deere 6610 forage harvesters (Moline, IL, USA). To minimize treatment differences in forage characteristics due to harvest location and time of harvest, alternate truckloads were harvested and delivered by two trucks concurrently to two Ag-Bag baggers® (Ag-Bag, Miller-St. Nazianz, Inc. Co., St. Nazianz, WI, USA) and compressed into the Ag-Bag® silos (3.0 m × 45.7 m; Ag-Bag Int. Ltd., Warrenton, OR, USA). Prior to delivery to the baggers, forage from each truck load was sampled. The samples from each truck were then thoroughly mixed, and used in a mini silo experiment to produce silage so fermentation characteristics and aerobic stability could be measured.

2.2. Mini silo experiment

2.2.1. Silage fermentation characteristics

Subsamples of each type of chopped forage (10.0 mm or 20.0 mm) were collected from each truck load at the time of delivery to the baggers. A 25-kg lot (3 lots/treatment) was then weighed and spread out on separate clean plastic sheets. Each lot was then sprayed with either 75 mL (3 mL/kg) of deionized water (uninoculated) or an equal volume of deionized water containing a commercially marketed FAE-producing silage inoculant (11GFT, Pioneer Hi-Bred Ltd., Chatham, Ontario, Canada) at a rate of 2.8×10^5 CFU of lactic acid-producing bacteria (LAB) per gram of fresh forage. This resulted in four treatments: short chop forage (10.0 mm; SC) without inoculant, inoculated short chop forage (10.0 mm; SC), long chop forage (20.0 mm; LC) without inoculant and inoculated long chop forage (20.0 mm; LC).

The inoculant contained 1.0×10^{11} CFU/g of FAE producing *Lactobacillus buchneri* LN4017 (ATCC PTA-6138), 2.0×10^{10} CFU/g of *Lactobacillus plantarum* LP7109 (ATCC PTA-6139), and 1.0×10^{10} CFU/g of *Lactobacillus casei* LC3200 (ATCC PTA-6135). Viability and label levels of the bacteria in the inoculant were confirmed prior to use.