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Effect of inoculated or ammoniated high-moisture ear corn on finishing performance of steers

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ABSTRACT

We investigated the effects of inoculated or ammoniated high-moisture ear corn (HMEC) on fermentation characteristics of silages, nutrient digestibility, nitrogen balance and finishing performance of steers. The HMEC was ensiled in both mini silos and press bags. The following treatments were compared: (1) Uninoculated HMEC (CO); (2) Homolactic bacterial inoculated HMEC (HOBI; *Lactobacillus plantarum* and *Enterococcus faecium* 0.91×10^5 cfu/g of fresh HMEC); (3) Heterolactic bacterial inoculated HMEC (HEBI; *Lactobacillus buchneri* 1.0×10^5 cfu/g of fresh HMEC); (4) Ammonia treated HMEC (AMMO; aqueous solution of NH_4OH, 295 g/kg NH_3, 0.90 kg/L was applied at 16 g/kg of fresh HMEC). For the finishing trial, 36 steers were fed HMEC-based diets over 142 days according to an incomplete block design. Four additional steers were used in a 4×4 Latin Square design to measure the nutrient digestibility and nitrogen balance of diets. The AMMO silage was highest in pH, ammonia, and soluble carbohydrates compared with CO, HOBI and HEBI silages. Digestibility of DM, OM, aNDF, ADF, and starch were not different ($P>0.15$) among treatments. Nitrogen retention was also not affected ($P>0.20$) by treatments. No impact ($P>0.15$) on body weight gain, gain to feed ratio, hot carcass weight, carcass yield and carcass grading of steers was observed during the finishing phase. In conclusion, inoculation of HMEC with homo- or hetero lactic bacteria or aqueous ammonia resulted in marginal changes in fermentation characteristics leading to similar diet digestibility and comparable performance during the finishing phase of steers.

1. Introduction

Ensiling high-moisture ear corn (HMEC) reduces fuel and labour costs when compared with artificial drying of corn grain. In addition, one advantage of harvesting HMEC lies in the fact that it can be harvested earlier which reduces field losses and allows seeding of late-maturing hybrids. However, HMEC may be more subject to aerobic conditions which can lead to spoilage. Slow filling rates, low packing density at the moment of ensiling and bad management of the silo face

Abbreviations: ADF, acid detergent fibre expressed inclusive residual ash; ADG, average daily gain; ADIN, acid detergent insoluble nitrogen; AMMO, high-moisture ear corn sprayed with aqueous ammonia; aNDF, neutral detergent fibre expressed inclusive residual ash; BW, body weight; cfu, colony forming units; CO, control high-moisture ear corn; DMI, dry matter intake; HEBI, high-moisture ear corn treated with the heterolactic bacterial inoculant; HOBI, high-moisture ear corn treated with the homolactic bacterial inoculant; HMEC, high-moisture ear corn; Lignin (sa), determined by solubilisation of cellulose with sulphuric; NDIN, neutral detergent insoluble nitrogen; NH_3-N, ammonia nitrogen; OM, organic matter; SEM, standard error of the mean; TMR, total mixed ration.

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may accentuate establishment of aerobic conditions in the silo. Consequently, yeasts may grow and metabolize lactic acid leading to an increase in silage pH to a point that opportunistic bacteria and moulds grow (McDonald et al., 1991). Such a phenomenon results in losses of dry matter (DM) and nutritive value which in turn might reduce animal performance (Whitlock et al., 2000).

To facilitate fermentation and reduce aerobic spoilage or both, a variety of additives are available. The efficiency of propionic acid (Sebastian et al., 1996) and buffered propionic acid-based additives (Ranjit and Kung, 2000; Kleinschmit et al., 2005) to inhibit growth of moulds and yeasts in corn silage and high moisture corn is largely documented. Ammonia applied to HMEC (Alli et al., 1983) reduced initial population of yeasts and moulds but prevented also the initial increase of populations of lactic acid bacteria. Elevated costs combined with recommended high application rates (3–6 g/kg of wet forage weight) and safety issues have limited the use of chemical additives on HMEC.

Homolactic bacterial inoculants containing *Lactobacillus plantarum* have been used to promote efficient fermentation of high-moisture corn. For *L. plantarum*, improved aerobic stability has been reported in corn silage diets (Wohlt, 1989). However, it seems that forage sources exert a strong influence on efficacy of inoculants. A review of the literature indicates that homofermentative inoculants were effective approximately 60% of the time with beneficial response often observed in grass and alfalfa silages while less than 50% in corn silage and 33% in whole-crop small grain silages (Much, 2010). Recently, the use of a heterolactic bacteria (*Lactobacillus buchneri*) has been shown to inhibit yeasts (Kleinschmit et al., 2005) and improve the aerobic stability of whole plant corn silage (Taylor and Kung, 2002). However, few studies have investigated the effect of heterolactic bacteria on the performance of finishing steers fed treated HMEC. For example, the effects of high concentrations of acetic acid in silages treated with *L. buchneri*, which may depress intake, could not be evaluated by a meta-analysis approach due to the very low number of publications on the subject and, therefore, still remains a subject of debate (Kleinschmit and Kung, 2006). Still today, only 50% of the studies using inoculants gave a positive animal response (Muck, 2010) and the reasons for that remain unclear.

To our knowledge, there are no reports evaluating in a single experiment, homolactic vs. heterolactic bacteria or aqueous ammonia applied specifically to HMEC on feedlot performance. Therefore, the current study was designed to compare the effect of homolactic vs. heterolactic bacteria or aqueous ammonia applied to HMEC on digestibility, N usage and performance of finishing steers.

2. Materials and methods

2.1. Harvest and treatment of HMEC

High-moisture ear corn (Hybrid DKC27-12, 2250 corn heat units, 670 g/kg DM ± 17) was harvested over four consecutive days using a New Holland 790 forage harvester equipped with 1 row corn head (New Holland). The knives were adjusted to obtain a majority of particles shorter than 7.5 mm. The forage was transported from the field to the storage area in self-unloading wagons (Dion HD185). Forage was placed on a conveyor belt where application of treatment was performed just prior to ensiling. The four large scale silos consisted of HMEC either (1) uninoculated (CO); (2) inoculated with a mixture of homolactic bacteria (HOBI, *L. plantarum* and *Enterococcus faecium*, Biomax Chr. Hansen A/S, Horsholm, Denmark); (3) or with a heterolactic bacterium (HEBI, *L. buchneri*, Pioneer 11A44, Pioneer Hi-Bred Ltd., Chatham, ON, Canada); or (4) treated with an aqueous solution of ammonia (AMMO). At the time of silo filling, loads of HMEC were either untreated or treated with the preparations according to manufacturer's recommendations. Microbial inoculants were applied at the rate of 1 g/ton of fresh HMEC, preparing 25 g of inoculant in 50 L of water and applying the solution at the rate of 2 L/ton of fresh HMEC. This provided 0.91×10^5 colony-forming-units per gram (cfu/g) of fresh HMEC with HOBI and 1.0×10^5 cfu/g of fresh HMEC with HEBI. Commercial ammonia (NH_4OH, 295 g/kg NH_3, 0.90 kg/L) was applied at a rate of 16 kg/ton of fresh material. Five repetitions of each treatment were also stored in mini silo (27.5 cm, diameter × 44 cm, height, 26 L capacity) to study HMEC fermentation. Each silo was filled with 16.2 kg of forage that was packed with a hydraulic press to a density of ~420 kg DM/m^3 and weighed prior to being filled and immediately after sealing the lid with thermoplastic (Mulco Inc. Montreal, Canada). Mini silos were stored in a temperature controlled room to mimic the external temperature where the large scale silos were stored. Temperature in the room was gradually decreased from +12 °C to 0 °C from October to December, kept between 0 °C and −5 °C from December to April and then increased gradually from 0 °C in April to 18 °C in June. For the large scale HMEC, four different pressed bag silos (Bag All, Klerk's Plastic Products Manufacturing Inc. Richburg, SC) were prepared using a silage compactor (Roto Press, Sioux Automation, Sioux City, IA), one allocated to each treatment. One day was required to complete each silo (15 tons DM ± 0.5 ton; 27 m length ± 1 m; 1.35 m diameter). The plastic pressed bags were placed on a concrete surface. All HMEC in mini silos were ensiled for 225 days while pressed bag silos were ensiled for 180 days prior to feed out in early May.

2.2. Finishing performance and digestion experiment

Experiments outlined below were approved by the local Animal Care and Use Committee of the "Centre de recherche en sciences animales de Deschambault" and animals were treated according to the Canadian Council on Animal Care (1993) guidelines.