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The effect of alfalfa (*Medicago sativa*) silage chop length and inclusion rate within a total mixed ration on the ability of lactating dairy cows to cope with a short-term feed withholding and refeeding challenge

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ABSTRACT

The objectives of the study were (1) to test whether 6 h of feed deprivation followed by refeeding induces an acidosis challenge in dairy cattle and (2) to quantify the acidosis challenge mitigation potential of increased alfalfa silage concentration in the diet. Alfalfa silage constituted either 25 or 75% of forage dry matter (DM) replacing corn silage [low (LA) or high alfalfa (HA)] and was chopped to either 14 or 19 mm theoretical length [short (S) or long (L)]. Dietary treatments LAS, LAL, HAS, or HAL were offered to 4 rumen-cannulated Holstein dairy cattle (161 d in milk; 5th or 6th parity) in a 4 × 4 Latin square design study with 21-d periods. Starch concentration was 69 g/kg of DM higher for LA diets than HA diets. Feed was withheld for 6 h followed by ad libitum refeeding on d 18 of each period. Measurements of DM intake, milk yield and composition, rumen pH, and eating and rumination behavior were taken on 1 baseline day, the challenge day, and 2 further recovery days. After refeeding, rumen pH was reduced in cows fed LA diets but not HA diets. Feeding LAL resulted in the greatest subclinical acidosis risk (pH <5.8 for 355 min on the first recovery day). Animals fed LA produced 4.4 L less milk on the challenge day in comparison to baseline. It was concluded that short-term feed deprivation detrimentally affected rumen health and milk yield in dairy cattle normally fed ad libitum, but had no effect on DM intake or milk composition. Feeding alfalfa silage in place of corn silage mitigated acidosis risk due to interrupted feed supply, likely due to a combination of lower starch concentration in HA diets, greater effective fiber concentration, and higher buffering capacity of alfalfa relative to corn silage.
Key words: alfalfa, chop length, acidosis, feed withholding, rumen challenge

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INTRODUCTION

Lactating dairy cow diets are often formulated to include a high concentration of rapidly fermented NFC as a source of energy to support milk production (Lechartier and Peyraud, 2011); however, such diets can also decrease rumen pH through greater rate of production of VFA (Allen, 1997). In circumstances where pH remains below 5.8 for 3 consecutive hours, a dairy cow is purported to suffer from SARA, a condition that can reduce milk yield and milk fat concentration (Plaizier et al., 2008). Dietary strategies to increase the resilience of dairy cattle to SARA include feeding forages with high buffering capacities (e.g., alfalfa, *Medicago sativa*) or increasing the concentration of physically effective fiber (**peNDF**) in the diet by lengthening forage chop length (McBurney et al., 1983; Zebeli et al., 2006). Physically effective fiber is defined as the NDF contained within particles that are longer than the critical particle size for rumen escape [which recent research suggests is 4 mm, although it was historically defined as 1.18 mm (Oshita et al., 2004; Maulfair and Heinrichs, 2012)] and therefore can contribute to the rumen mat (Mertens, 2000). A lower rumen pH has also been linked with changes in cow feeding behavior and the adoption of coping mechanisms, including showing preferences for long particles in the diet (DeVries et al., 2008; Maulfair et al., 2013) or for supplementary hay (Kmicikewycz and Heinrichs, 2015).

Experimentally, the stability of rumen pH can be tested by induction of a rumen fermentation challenge. This is typically achieved through the addition of a large quantity of a rapidly degradable carbohydrate to the diet, such as cereal grains or alfalfa pellets (Krause and Oetzel, 2005; Colman et al., 2013). However, it is unclear whether such a method accurately replicates conditions that cause SARA and, furthermore, may not provide an appropriate model for evaluating dietary mitigation strategies. An alternative approach to instigate a rumen challenge is deprivation of feed for a period of several hours (Oetzel, 2007). A period of fasting is then followed by a period of overeating when access to feed is returned, termed refeeding (Chilibroste et al., 2007). Periods of feed deprivation lasting up to 6 h may be relatively common in a commercial setting; for instance, where insufficient feed or pasture is allocated, during feeding equipment failure, or when the animal's access to feed for routine processes such as milking or health checks is removed. However, relatively little is known about the severity of the effect of such events on rumen function and milk production. Studies in the literature have examined the effect of longer periods of fasting, such as 12 to 48 h (Chelikani et al., 2004; Oetzel, 2007; Toerien and Cant, 2007), that generally result in high levels of temporary milk yield loss; however, we are not aware of any studies that have examined the effects of shorter fasting periods in dairy cattle that would be more representative of commercial practice. Therefore, the aims of the present study were (1) to test whether 6 h of feed deprivation followed by refeeding induces an acidosis challenge and (2) to examine the effect of varying inclusion rate (**IR**) and chop length (**CL**) of alfalfa silage replacing corn silage in a TMR on resilience to a feed withholding and refeeding challenge.

MATERIALS AND METHODS

Forage Harvesting and Clamp Sampling

The present study formed part of a larger research trial that used the same dietary treatments and observed their effects on milk yield, DMI, diet digestibility, and rumen function under nonchallenging conditions in a larger cohort of cows and over a longer time period, as reported previously (Thomson et al., 2017a,b). In brief, alfalfa silage was harvested as a second cut crop at an estimated 10% bloom in July 2014 and conserved in concrete-walled clamps. The crop was wilted for 48 h and ensiled, producing a high-DM (576 g/kg of fresh weight) silage. Two CL [long (**L**) and short (**S**)] were created from material collected in alternate swaths by altering the knife arrangement of the precision chop forage harvester (Claas Jaguar, Claas Group, Harsewinkel, Germany) from a theoretical chop length of 14 (shortest setting) to 19 mm (longest setting) that were ensiled in 2 adjacent clamps. An additive was applied (Axcool Gold containing *Lactobacillus buchneri*; 2 L/t; Biotal, Cardiff, UK) to prevent heating in the clamp. Samples for chemical composition analysis (Sciantec Analytical Services, Cawood, UK) were obtained using a clamp corer. A detailed analysis of the particle length profile of the silages produced (mean 14.3 and 9.0 mm for L and S, respectively) has been published previously (experiment 2; Thomson et al., 2017b). Corn (*Zea mays*) silage for the study was taken from a commercial crop of mixed varieties harvested in autumn 2014 that was chopped by the forage harvester (Model FR700, New Holland Ltd., Turin, Italy; theoretical chop length of 18 mm) and ensiled as described for the alfalfa clamps [geometric mean particle length of 10 mm determined using a Penn State particle separator (**PSPS**); Heinrichs, 2013].

Diets

Diets comprised a TMR with 50:50 ratio of forage to concentrate on a DM basis (Thomson et al., 2017a,b), in which the forage portion consisted of corn and alfalfa silage at IR (DM basis) of either 25:75 (high alfalfa; **HA**) or 75:25 (low alfalfa; **LA**), respectively. These treatments were combined with the 2 alfalfa silage CL in a 2 × 2 factorial arrangement to give 4 treatments (**HAL**, **HAS**, **LAL**, and **LAS**) that were formulated to be isonitrogenous (170 g of CP/kg of DM) and contain similar levels of NDF (320 g/kg of DM). The reduction in corn starch associated with the lower corn silage inclusion in HA diets was partially offset by increasing the concentration of corn meal (Table 1); however, for the experimental diets fed, starch concentration was still lower in the HA diets (Table 2).

Animals

Four multiparous Holstein dairy cows, previously prepared with rumen fistulae (Bar Diamond rumen cannula; Parma, ID), in mid-lactation (161 DIM, SE ± 23.1), weighing 739 kg (SE ± 13.9), and 7 to 9 yr of age (5th or 6th parity), were randomly assigned to 1 of 4 initial treatments according to a 4 × 4 Latin square design balanced for carryover effects with 21-d periods. All procedures were licensed and monitored by the UK Government's Home Office under the Animal (Scientific Procedures) Act 1986. The experimental design and replication employed was based on variance and expected treatment effects for key variables observed in previous studies (Reynolds et al., 2014). During adaptation weeks (wk 1 and 2 of each period), animals were housed in a cubicle yard and individually fed once daily for ad libitum intake (10% refusals) through Insentec RIC feeders (Insentec B.V., Marknesse, the Netherlands). Continuous access to water was provided. From d 12 of each period, animals were housed and milked in individual tiestalls to facilitate sampling. Animals were allowed to acclimatize to the stalls for 3 d before sampling beginning on d 15. While in tiestalls, animals were offered their daily feed allocation in 2 halves at 1000 and 1600 h. Refusals were taken daily at 0930 h. Between d 15 and 18, measurements of rumen func-