



Addition of potassium carbonate to continuous cultures of mixed ruminal bacteria shifts volatile fatty acids and daily production of biohydrogenation intermediates

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ABSTRACT

A recent study reported a 0.4 percentage unit increase in milk fat of lactating dairy cattle when dietary K was increased from 1.2 to 2% with potassium carbonate. Because milk fat yield has been associated with ruminal production of certain conjugated linoleic acid (CLA) isomers, 2 studies were conducted to determine if increasing potassium carbonate in the rumen would alter patterns of fermentation and biohydrogenation. In experiment 1, 5 dual-flow continuous fermenters were injected just before each feeding with a 10% (wt/wt) stock potassium carbonate solution to provide the equivalent of 1.1 (K1), 2.2 (K2), and 3.3 (K3) % of diet dry matter (DM) as added K. One of the remaining fermenters received no K (K0) and the last fermenter (NaOH) was injected with adequate NaOH stock solution (10%, wt/wt) to match the pH observed for the K3 treatment. For experiment 2, 6 dual-flow continuous fermenters were used to evaluate 6 treatments arranged in a 2 × 3 factorial to examine 2 levels of soybean oil (0 and 3.64% of diet DM) and added K at 0, 1.6, and 3.3% of diet DM. In both experiments, fermenters were fed 55 to 57 g of DM/d of a typical dairy diet consisting of 1:1 forage (10% alfalfa hay and 90% corn silage) to concentrate mix in 2 equal portions at 0800 and 1630 h, and fed the respective diets for 10-d periods. Potassium carbonate addition increased pH in both experiments. Acetate:propionate ratio and pH in experiment 1 increased linearly for K0 to K3. Acetate:propionate ratio was lower for NaOH compared with K3 but the pH was the same. The *trans*-11 18:1 and *cis*-9,*trans*-11 CLA production rates (mg/d) increased linearly from K0 to K3, but K3 and NaOH did not differ. Production of *trans*-10 18:1 decreased and that of *trans*-10,*cis*-12 tended to decrease from K0 to K3, but production of *trans*-10,*cis*-12 CLA remained high for NaOH. Addition

of K to the cultures in experiment 2 decreased propionate and increased acetate and acetate:propionate ratio for the 0% fat diet but not for the 3.64% fat diet. Addition of K increased stearic acid and *cis*-9,*trans*-11 CLA but decreased daily production of *trans*-10 C18:1 and *trans*-10,*cis*-12 CLA. The results indicate that increasing potassium carbonate in the diet shifts both fermentation and biohydrogenation pathways toward higher milk fat percentage in dairy cows, but the effects are only explained in part by elevation of pH.

Key words: potassium carbonate, biohydrogenation, mixed ruminal bacteria, continuous culture

INTRODUCTION

Diet-induced milk fat depression (MFD) continues to have a major economic impact in the dairy industry and finding solutions for MFD remains a priority. The biohydrogenation theory links MFD with the formation of several active conjugated linoleic acid (CLA) isomers produced by the rumen microbial population, including *trans*-10,*cis*-12 CLA (Baumgard et al., 2000), *trans*-9,*cis*-11 CLA (Perfield et al., 2007), and *cis*-10,*trans*-12 CLA (Saebø et al., 2005). These 3 isomers, and many others, arise from the biohydrogenation of linoleic (Lee and Jenkins, 2011a) and linolenic acids (Lee and Jenkins, 2011b). Formation of the CLA isomers that cause MFD has been associated with several dietary risk factors, including excessive fat intake and low rumen pH. Solutions to solving MFD are complicated by interactions that often exist among two or more risk factors, making the process of reversing MFD slow and frustrating.

Some studies examining the effects of DCAD on lactation performance have reported improvements in milk fat. For example, in a study by Hu et al. (2007), increasing DCAD from a combination of calcium chloride, sodium bicarbonate, and potassium carbonate increased milk fat up to 0.77 percentage units in dairy cows. A more recent study (Harrison et al., 2012) increased DCAD using only potassium carbonate ses-

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quihydrate and increased milk fat 0.4 percentage units (from 4.0 to 4.4%).

The objective of this study was to determine if the improvement in milk fat percentage reported previously might have been caused by potassium carbonate influencing the type of CLA produced in the rumen. An initial experiment was done in continuous culture to establish whether CLA production was altered when the cultures were exposed to an increasing dosage of potassium carbonate and also to evaluate the possible influence of pH. After observing a CLA shift resulting from potassium carbonate addition in the first experiment, we conducted a second experiment to determine if the CLA changes caused by potassium carbonate were dependent on fat concentration in the diet.

MATERIALS AND METHODS

Experiment 1

Treatments consisted of 4 dosage levels of a 10% K₂CO₃ (wt/wt) stock solution (0, 10.6, 21.2, and 32 mL) injected directly into the fermenters twice daily immediately after each feeding. Distilled water was also injected (32, 21.4, 10.8, and 0 mL, respectively) to maintain a total injection volume of 32 mL/d for all treatments. The K was supplied at 0, 0.6, 1.2, and 1.8 g/d or 0 (K0), 1.1 (K1), 2.2 (K2), or 3.3% (K3) of the

daily feed DM. Because aqueous solutions of K₂CO₃ are strongly alkaline, pH was expected to increase with increasing dosage of K₂CO₃. To determine if any changes in biohydrogenation and fermentation could be attributed to effects on pH, a fifth treatment (NaOH) consisted of injection of sufficient 10% NaOH (wt/wt) each day to match the pH of K3.

Each treatment was randomly assigned to 1 of 5 continuous fermenters and run for a 10-d period with 7 d for adaptation and 3 d for sample collection. Four periods were run for each treatment. Each period began with a clean fermenter inoculated with fresh ruminal contents from a fistulated cow. A total of 54.5 g of diet DM (Table 1) was fed to each fermenter daily in 2 equal portions at 0800 and 1630 h.

Experiment 2

Six treatments were examined in experiment 2 arranged as a 2 × 3 factorial with 2 levels of added soybean oil and 3 levels of added K. Fat levels were no added fat (low fat; **LF**) or 3.64% of DM (high fat; **HF**) to bracket the intermediate fat level (2.19%) used in experiment 1. Potassium was introduced by injection of a 10% K₂CO₃ (wt/wt) stock solution (0, 16, and 32 mL/d) directly into the fermenters twice daily immediately after each feeding. Distilled water was also injected (32, 16, and 0 mL/d, respectively) to maintain

Table 1. Diet composition and nutrient inputs into fermenters in experiments 1 and 2

Item	Experiment 1	Experiment 2 ¹	
		LF	HF
Ingredient, % of DM			
Corn silage	45.3	45.2	45.1
Alfalfa hay	5.2	5.1	5.1
Ground corn	19.1	21.1	19.6
Soybean oil	2.19	0.0	3.64
Soybean meal	11.9	12.1	11.2
Soybean hulls	12.9	13.1	12.2
Calcium phosphate	1.33	1.37	1.27
Limestone	0.64	0.65	0.61
Trace mineral salt	0.61	0.62	0.58
Sodium bicarbonate	0.81	0.81	0.75
Nutrient input per fermenter, g/d			
DM	54.6	54.6	56.9
CP	8.6	8.9	9.1
K	0.59	0.61	0.61
Ca	0.45	0.47	0.47
P	0.29	0.31	0.30
FA, mg/d	2.42	1.64	3.75
16:0	312	219	439
18:0	83	51	154
18:1	477	316	801
18:2	1,185	714	1,793
18:3	158	88	223
Total	2,427	1,637	3,750

¹Nutrients supplied by the low-fat (LF) and high-fat (HF) diets in experiment 2 were equalized by adjusting diet composition and amounts fed to provide the same nutrient input (except FA) into each fermenter per day.

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