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Short communication: Temporal effect of feeding potassium carbonate sesquihydrate on milk fat in lactating dairy cows fed a fat-depressing diet

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ABSTRACT

A lactation study with 10 multiparous dairy cows in early lactation, with an average of 64 days in milk (standard deviation = 37), were used to evaluate how quickly milk fat concentration would change when potassium carbonate sesquihydrate was abruptly added to the diet. The experiment had 3 periods. In period 1 (d 0 to 7) all cows were fed the same basal (control) diet with 1.8% soy oil, dry basis; in period 2 (d 8 to 28) 5 cows received the control diet, whereas the other 5 cows received the control diet plus 0.59% of added K with K carbonate sesquihydrate; and in period 3 (d 29 to 42) all 10 cows received the control diet. The control diet was formulated for a dietary cation-anion difference (DCAD), calculated as Na + K − Cl − S, of 37.7 mEq/100 g of dry matter (DM), 1.74% of DM as K, and 5.7% long-chain fatty acids (DM%), which included 1.8% of DM as soybean oil. Period 1 was used as a covariate. In period 2, d 8 to 28, 5 cows remained on the control diet whereas 5 cows were fed with the control diet plus K carbonate sesquihydrate (DCAD+ diet; DCAD of 54.3 mEq/100 g DM and 2.33% of DM as K). After feeding the DCAD+ diet, we noted a difference in milk fat concentration from 3.9 to 4.3% within 72 h. Over the 21 d of period 2, the DCAD+ diet resulted in significantly greater milk fat percentage from 4.0 to 4.3%, lactose from 4.74 to 4.82%, and fat efficiency in the form of fat in milk divided by fat in DMI from 1.27 to 1.49, without affecting dry matter intake (DMI), milk protein concentration, solids-not fat concentration, 3.5% fat-corrected milk, and protein efficiency in the form of protein in milk divided by protein in DMI. In period 3 (d 29–42), all cows were again fed the control diet, resulting in a tendency for greater milk fat concentration, significantly greater lactose concentration, and fat efficiency in the form of fat in milk divided by fat in DMI for the cows having received the DCAD+ diet during period 2. In conclusion, the abrupt addition of K carbonate sesquihydrate resulted in a greater milk fat concentration and tended to maintain the greater concentration after cessation of K carbonate sesquihydrate feeding.
Key words: potassium, milk fat, milk fat depression

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Sanchez et al. (1994) reported that when DCAD was between 30 and 50 mEq/100 g of dietary DM (DCAD = Na + K − Cl), 3.5% FCM and DMI were maximized with mid-lactation dairy cows (80 to 210 DIM). Milk fat concentration was greatest when Na was 0.6% DM, K was 1.34% DM, and Cl was 0.69% DM; likewise, there was an additive effect of dietary K and sodium supplementation in improving DMI and milk fat concentration of dairy cows (Sanchez et al., 1994). A more recent report (Harrison et al., 2012) indicated an increase in milk fat (4.38 vs. 4.01% milk fat) in cows not showing fat depression when fed a DCAD of 53 mEq/100 g of dietary DM (DCAD = Na + K − S − Cl) and 2.07% K DM. Harrison et al. (2012) also observed an increase in raw milk yield (39.5 vs. 41.6 kg/d), which was consistent with the optimal effect of DCAD supplementation suggested by Iwaniuk and Erdman (2015). In addition, it was observed that when K carbonate sesquihydrate was fed, the proportion of *trans*-10 C18:1 (0.68 vs. 0.40% of total fatty acids) in milk decreased, and it was suggested that feeding K carbonate sesquihydrate could affect ruminal biohydogenation pathways (Harrison et al., 2012).

Increased *trans*-10,*cis*-12 CLA is suggested to cause milk fat depression in dairy cows (Baumgard et al., 2001). When cows exhibit milk fat depression, the biohydrogenation pathways could be altered and result in more *trans*-10,*cis*-12 CLA and *trans*-10 C18:1, and

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less *cis*-9,*trans*-11 CLA and *trans*-11 C18:1 (Grinari and Bauman, 1999). Jenkins et al. (2014) conducted fermenter studies to evaluate the effect of increased K supplementation on biohydrogenation and observed that *trans*-10 C18:1 decreased linearly, whereas *trans*-11 C18:1, *trans*-9,*trans*-11 C18:2, and *cis*-9,*trans*-11 C18:2 increased linearly, and the explanation of the effect of K was due to a change of pH.

Harrison et al. (2012) demonstrated the advantages of additional K on milk performance of early-lactating dairy cows, however, it was not established how quickly milk fat concentration would change when K carbonate sesquihydrate was supplemented. The specific objective of the current in vivo study was to determine how quickly the addition of dietary K would affect milk fat concentration, as well as to demonstrate differences in concentration of milk *trans*-11 C18:1 in relation to the addition of K carbonate sesquihydrate based on a milk fat-depressing basal diet with added soy oil.

Our study was approved by the Institutional Animal Care and Use Committee at Washington State University (IACUC protocol #04321-001). Ten multiparous dairy cows were assigned to the study with an average of 64 (SD = 37) DIM and the experiment was conducted between December 2012 and January 2013. The cows were blocked by predicted transmitting ability and separated into 5 pairs. The control diet was formulated to contain a DCAD (Na + K –S – Cl) of 37.7 mEq/100 g of DM (1.74% K of DM), 5.7% DM as long-chain fatty acids, and 1.80% of diet DM soybean oil. The DCAD+ diet consisted of the control plus 0.59% added K and 16.6 mEq/100 g of DM increased DCAD by adding K carbonate sesquihydrate (DCAD Plus, Church & Dwight Inc., Princeton, NJ) and added soybean oil to 1.73% of diet DM. The soybean oil was added to induce milk fat depression. In wk 1 (period 1), all the cows were fed control diet. In wk 2 to 4 (period 2), half of the cows were abruptly changed to the DCAD+ diet. In wk 5 and 6 (period 3), the DCAD+ cows were again fed the control diet. Period 1 was used as covariate for periods 2 and 3.

Cows were housed in a freestall facility bedded with composted manure. Rations were formulated using AMTS Cattle Pro version 3.3.x (2012, AMTS LLC, Groton, NY). The ration ingredients (DM basis) were corn silage 26.2%, alfalfa hay 25%, timothy hay 3.6%, cottonseed 4.8%, corn distillers 6.5%, and grain mix 33.9% (Table 1). The difference between the DCAD+ and control diet was the inclusion of K carbonate sesquihydrate in the grain mix, as shown in Table 1. Diet ingredients were mixed in a mixer wagon (Roto Mix 533–16 Hay Pro, Industrial Systems and Fabrication Inc., Spokane, WA). The TMR was transferred into a Calan Super Data Ranger (American Calan, Northwood, NH) for feed delivery into individual feed bunks. Cows were fed individually using Calan gates once per day between 1000 and 1200 h. Feed was offered as 5 to 10% excess of the previous day's intake. Samples of TMR and grain mix were obtained 1 d per week. Subsamples of the TMR were analyzed for DM, CP, starch, ether extract, ADF, NDF, ash, Ca, P, K, Na, Cl, and S (Table 2) by wet chemistry (Cumberland Valley Analytical Services, Hagerstown, MD).

Cows were milked twice daily (1100 and 2300 h), and milk weights were recorded at each milking. Daily morning and evening composite milk samples were collected and sent to Minnesota DHIA (Zumbrota, MN) for analysis (fat, protein, casein, lactose, SCC, and MUN). Additional individual morning and evening milk samples were collected on the last 2 consecutive days of period 1 and the first 4 consecutive day of pe-

Table 1. Ingredients in control and DCAD+ TMR

Item, % of DM	Control	DCAD+
Corn silage	26.2	26.2
Alfalfa hay	25	25
Timothy hay	3.6	3.6
Whole cottonseed	4.8	4.8
Corn distillers	6.5	6.5
Barley, ground	14.9	14.4
Corn grain, ground	8.7	8.3
Soybean meal, 44 CP	5.0	4.8
Soybean oil	1.8	1.7
DCAD+[1]	0.00	1.20
Megalac[1]	0.95	0.92
Sodium sesquicarbonate[1]	0.94	0.90
Calcium phosphate monobasic	0.41	0.39
Calcium carbonate	0.35	0.34
Trace mineral salt with selenium[2]	0.29	0.28
Magnesium oxide	0.25	0.24
MetaSmart[3]	0.13	0.12
Brewers yeast[4]	0.05	0.05
Yeast culture[5]	0.05	0.05
Diamond V seleno source 2000[5]	0.01	0.01
Bloat guard[6]	0.05	0.05
Zinpro4 plex[7]	0.04	0.04
Mineral oil	0.03	0.03
Vitamin D_3 premix[8]	0.02	0.02
Vitamin A premix[9]	0.02	0.02
Vitamin E premix[10]	0.003	0.003

[1]Church and Dwight Co. Inc., Princeton, NJ.

[2]Contained 97.5% NaCl, 0.009% Se, 0.006% Co, 0.01% I, 0.035% Cu, 0.20% Fe, 0.18% Mn, 0.037% Mg, and 0.35% Zn.

[3]MetaSmart, Adisseo, Alpharetta, GA.

[4]Integral, Alltech Inc., Nicholasville, KY.

[5]Diamond V Mills Inc., Cedar Rapids, IA.

[6]Phibro Animal Health (Pty) Ltd., Teaneck, NJ.

[7]4-Plex, Zinpro Corp., Eden Prairie, MN.

[8]Contains 8,818,400 IU of vitamin D_3 per kg.

[9]Contains 30,000 IU of vitamin A-acetate per g.

[10]Contains 500,044 IU of vitamin E per kg.