Research Bulletin
Arm & Hammer Animal Nutrition
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DCAD Plus Increases Milk Fat Production Through More Complete Rumen Biohydrogenation

Stabilized potassium carbonate alters the rumen biohydrogenation patterns to produce more favorable fatty acid intermediates.

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KEY POINTS

- **Multiple trials from Clemson University have shown a positive influence on rumen biohydrogenation when potassium from DCAD Plus® Stabilized Potassium Carbonate was evaluated in cultures of rumen microorganisms. Research confirms potassium can help reduce the incidence and severity of milk fat depression by allowing for more of the desirable rumen biohydrogenation pathway to occur.**
- **When different potassium sources were compared, DCAD Plus outperformed potassium chloride, leading to the conclusion that chloride may negatively impact the production of desirable fatty acid intermediates.**

INTRODUCTION

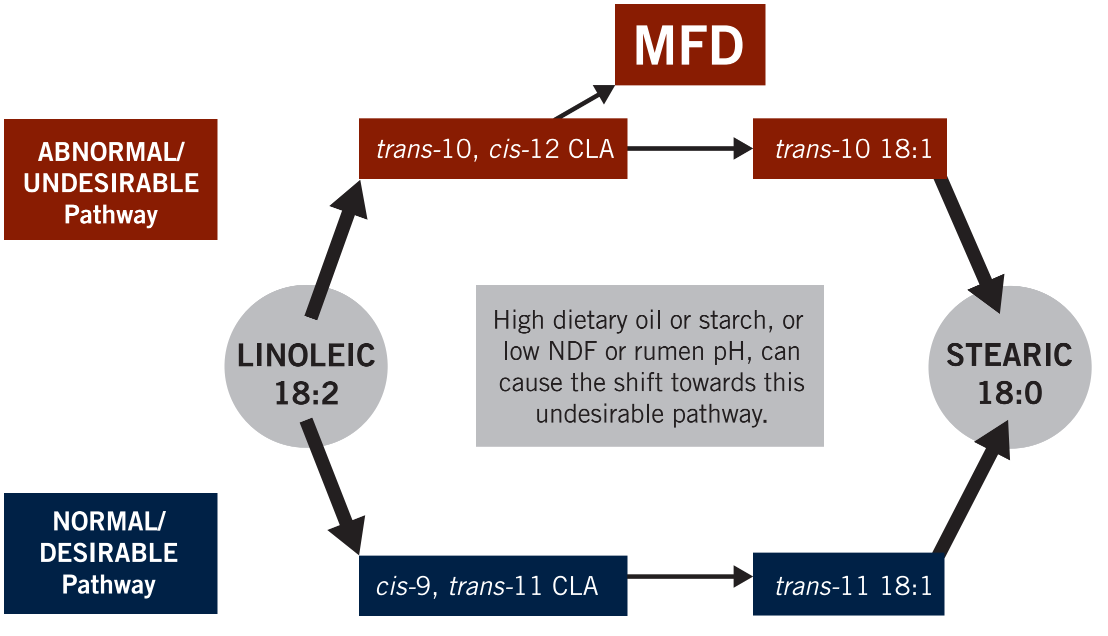
Milk fat depression (MFD) is an ongoing challenge for dairy producers and can have a direct impact on dairy profitability. Because it can cause major economic losses, finding solutions to reduce MFD and increase total fat production is critical.

MFD can be the result of multiple factors and feeding practices including source and amount of grain, source and amount of fat and effective fiber levels. Based on ration formulation, different fatty acid intermediates can be created in the rumen, which will ultimately determine if normal biohydrogenation or MFD occurs. Figure 1 depicts the rumen biohydrogenation pathways and demonstrates that rumen biohydrogenation can either take place in the normal/desirable pathway or by the abnormal/undesirable pathway. The abnormal pathway leads to MFD.

Research conducted at Washington State University[1] in 2008 found a potential nutritional intervention to fight MFD: potassium. In the study, cows fed DCAD Plus®—a stabilized potassium carbonate source—produced significantly more fat-corrected milk and milk fat pounds than the control group not fed supplemental potassium. While the boost in milk production was expected due to previous research[2] related to increasing ration Dietary Cation-Anion Difference (DCAD) postpartum, the increase in milk fat was a new finding.

The conclusions from the Washington State University trial led to more questions—why and how did DCAD Plus increase milk fat? What role may potassium play in combating milk fat depression? Can any potassium source improve fat production or is DCAD Plus the better alternative?

FIGURE 1 Biohydrogenation Pathways in the Rumen Related to MFD[3]



To better understand the role potassium carbonate played in milk fat production, two rumen fermenter trials were conducted at Clemson University. The first was designed to determine the specific role potassium plays in milk fat production and the second compared different potassium sources and their potential impact on biohydrogenation.

TRIAL 1: DESIGN & METHODS[3]

Five diets were evaluated using dual-flow continuous fermenters. All diets were formulated with the same feeds; the only difference was the level of potassium carbonate fed as the added potassium (K) source, as noted in Table 1.

TABLE 1

DIET NAME	POTASSIUM LEVEL	TOTAL DIETARY POTASSIUM
K0 (control)	0 mL (0 g/d; 1% dietary K)	1%
K1	10.6 mL (0.6 g/d; 1% added K)	2%
K2	21.2 mL (1.2 g/d; 2% added K)	3%
K3	31.8 mL (1.8 g/d; 3% added K)	4%
NaOH	Diet was used to determine if rumen pH was a factor.	—

- Supplemental potassium was injected into the fermenters two times per day.
- Distilled water was also injected to maintain a volume of 32 mL.

TRIAL 1 RESULTS

Higher Rumen pH

- Rumen pH increased as the level of potassium increased.
  - This result was anticipated based on potassium's basic properties and previous research findings.[2]
- Changes in biohydrogenation intermediates were also caused by the NaOH treatment, suggesting potassium might shift biohydrogenation due to pH elevation.

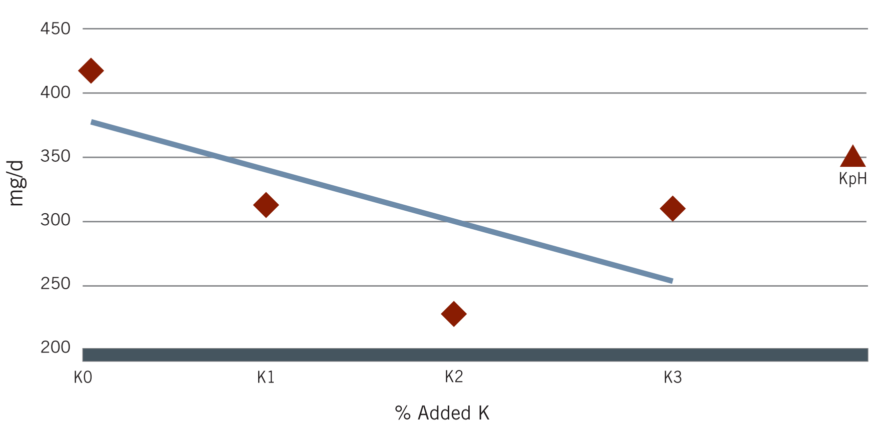
More Stearic Acid

- As potassium levels increased, there was a trend of increasing stearic acid.
- Theoretically, the only way that this could occur is if the biohydrogenation process in the rumen was performing faster or more completely.

Shift in Biohydrogenation Pattern

- As potassium increased, production of *trans*-10 C18:1—an intermediate fatty acid known to be associated with MFD—numerically decreased, as shown in Chart 1.

CHART 1 *trans*-10 C18:1 Levels by Diet



The amount of intermediates associated with the normal (desirable) pathway of biohydrogenation increased with higher supplemental potassium levels, as outlined in Table 2.

TABLE 2 Fatty Acid Levels by Treatment

FATTY ACID, mg/d	K0	K1	K2	K3	SE
n	4	4	4	4	–
t-68 C18:1	34.1	34.5	35.7	32.7	4.0
t-9 C18:1	17.6	18.8	18.9	16.7	1.9
t-11 C18:1[a]	46.9	108.9	144.8	167.3	16.6
t-12 C18:1	23.4	25.4	25.5	18.9	2.7

[a]Linear response of K0 through K3 ($P<0.05$)

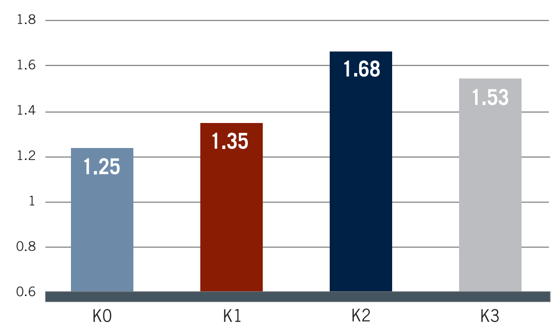
Increase in Acetate-to-Propionate Ratio

- As potassium levels increased, so did the acetate:propionate ratio, which has been associated with higher milk fat levels.

Conclusions

- The milk fatty acid profiles indicate the normal biohydrogenation pathway is favored as potassium from DCAD Plus® is increased, which was consistent with the animal trial conducted and reported by Washington State University.[1]

CHART 2 Acetate-to-Propionate Ratio[a]



[a] Linear effect of K

TRIAL 2: DESIGN & METHODS[4]

As a follow-up to trial #1, researchers investigated if the potassium source would impact rumen biohydrogenation.

The second trial design had six rations—three with added fat and three without any additional fat source. The control diets had no supplemental potassium, and potassium carbonate from DCAD Plus and potassium chloride were used as the added potassium sources in the remaining diets. Table 3 below outlines the six diets further.

TABLE 3

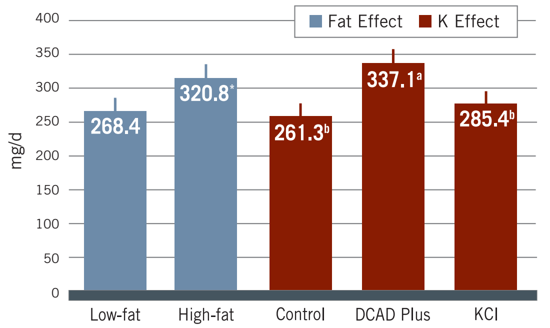
ADDED K (% OF DIET)	0% ADDED K (CONTROL)		3% K FROM DCAD PLUS		3% K FROM KCI	
TOTAL K (% OF DIET)	1% (CONTROL)		4% K		4% K	
Added Soybean Oil (% of Diet)	0	3	0	3	0	3
Total Fat (% of Diet)	2	5	2	5	2	5

The continuous fermenters were fed 60 grams/day of 1:1 forage (alfalfa dehydrated pellets) to concentrate mix twice daily.

TRIAL 2 RESULTS

The charts in this section demonstrate the impact of the low-fat and high-fat diets, irrespective of the potassium effect. Conversely, they also show the impact of potassium source, irrespective of the fat effect.

CHART 3 C18:0 Daily Outflow



* Fat effect (P<0.05)
ab K means without a common letter differ (P<0.05).

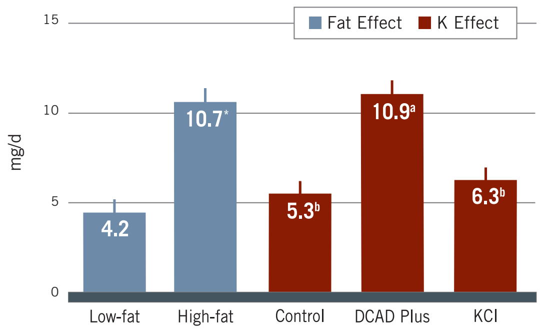
More Complete Biohydrogenation

- DCAD Plus diets had more stearic (C18:0) acid, but this was reversed with potassium chloride (KCl).
- DCAD Plus increased the completeness of biohydrogenation, but the potassium chloride diets did not.

Improved Production of Desirable Intermediates

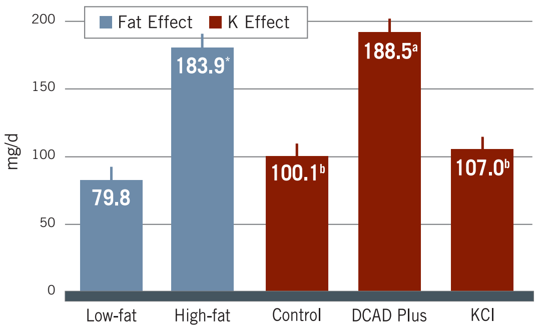
- Intermediates associated with the "desirable" biohydrogenation pathway are increased by DCAD Plus but not by potassium chloride.

CHART 4 *cis*-9 *trans*-11



* Fat effect (P<0.05)
ab K means without a common letter differ (P<0.05).

CHART 5 *trans*-11 18:1

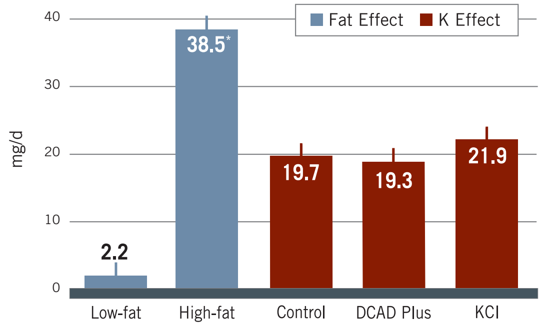


* Fat effect (P<0.05)
ab K means without a common letter differ (P<0.05).

Decreased Production of Undesirable Intermediates

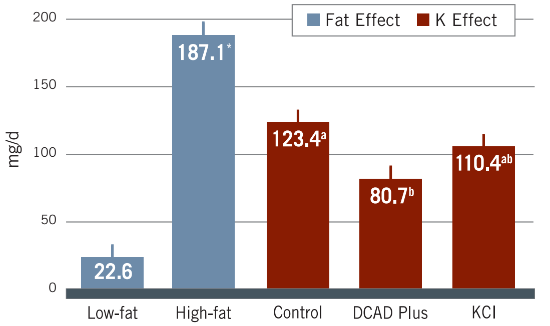
- Intermediates associated with MFD increased when potassium chloride was fed and decreased with DCAD Plus.
- While more of the intermediates associated with MFD were produced in higher-fat diets, feeding DCAD Plus can reverse this trend more effectively than potassium chloride.

CHART 6 *trans*-10 *cis*-12



* Fat effect (P<0.05)

CHART 7 *trans*-10 18:1



* Fat effect (P<0.05)
ab K means without a common letter differ (P<0.05).

- The acetate:propionate ratio also increased with DCAD Plus, supporting findings from Trial #1. Potassium chloride performed similarly to the control diet.

CONCLUSIONS

- Potassium from DCAD Plus caused more complete biohydrogenation of rumen fatty acids via the desirable biohydrogenation pathway compared to the control.
  - Benefits associated with increasing dietary potassium with DCAD Plus were not observed when potassium chloride was used as the source of dietary potassium.
- Researchers concluded that chloride must have negated the positive effects associated with additional potassium in the rumen.
- Results from the Clemson University trials reinforce the higher milk fat results seen in the previous on-farm work at Washington State University.

DISCUSSION

There are many nutrition and management factors that ultimately impact the incidence of milk fat depression, and no single factor can be pinpointed as the cause. However, these research studies confirm that feeding potassium carbonate from DCAD Plus can be a nutritional solution to increase desirable intermediate fatty acids associated with milk fat production.

Additional work is underway to further understand the mechanisms by which DCAD Plus and potassium influence rumen biohydrogenation. These studies will investigate the effects of DCAD Plus with and without Rumensin® on fatty acid biohydrogenation. A second study will investigate the dietary effects of potassium on feed efficiency and feed efficiency response to potassium or sodium at equal ration Dietary Cation-Anion Difference (DCAD) levels.

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1 Harrison J, White R, Kincaid R, Block E, Jenkins T, St. Pierre N. Effectiveness of potassium carbonate sesquihydrate to increase dietary cation-anion difference in early lactation cows. *J Dairy Sci* 2012;95:3919-3925.

2 DCAD Nutrition for Dairy Cattle Research Summary. Church & Dwight Co., Inc. 2010:23–25.

3 Jenkins TC, Block E, Harrison JH. Shifts in fermentation and intermediates of biohydrogenation induced by potassium supplementation into continuous cultures of mixed ruminal microorganisms, in *Proceedings*. 2010 ADSA Annual Meeting July 11 – 15, 2010 Denver, Colorado; Abstr. 746. Data on file.

4 Morris PH, Andrae JG, Bernard JK, Block E, Jenkins TC. Volatile fatty acids and biohydrogenation intermediates in continuous cultures are returned to normal by addition of potassium carbonate but not by potassium chloride. *J Anim Sci* 2012;90:(Suppl.3, Abstr.179)/*J Dairy Sci* 2012;95:(Suppl.2, Abstr.179). Data on file.

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