

Paying Attention to Dietary Cation-Anion Balance Can Mean More Milk and Fewer Metabolic Problems

Charles C. Stallings, Professor and Extension Dairy Scientist, Virginia Tech

Dietary cation-anion difference (DCAD) or balance can be used to alter the metabolic status of both dry and lactating cows. Research demonstrates that dry cows can benefit from a mild systemic acidosis at calving, resulting in improved bone calcium mobilization. Lactating cows benefit from a mild systemic alkalosis that buffers acids produced during ruminal digestion. By keeping a proper balance of cations and anions, producers can maintain healthy cows that eat well with minimal metabolic problems.

DCAD is calculated by subtracting the milliequivalents of positively charged cations, sodium and potassium, from the negatively charged anions, sulfur and chlorine. If more milliequivalents of cations are available, then the charge is positive and if more anions are present,

then the charge is negative. Both feeds and rations can have a DCAD value calculated as long as concentrations of the four elements are known.

Lactating cows need more cations than dry cows because of their increased requirements for sodium (Na) and potassium (K). Excess Na and K should be avoided in late gestation, dry-cow diets. Cations are desirable in lactating cow diets.

A recent research report by Georgia workers (Chan *et al*, 2005) formulated diets containing target DCAD levels of +20, +35, and +50 for early lactation Holstein cows. The cation sources consumed in grams of dry matter per day and the cation and anion concentrations in the rations were:

<u>DCAD</u>	<u>+20</u>	<u>+35</u>	<u>+50</u>
Sodium sesquicarbonate, grams	130	200	240
Potassium carbonate, grams	50	170	260
Sodium, %	0.45	0.49	0.63
Potassium, %	1.3	1.6	2.1
Sulfur, %	0.33	0.31	0.29
Chlorine, %	0.30	0.30	0.29
Calculated DCAD	+24	+35	+55

The animal response to the different DCAD diets was:

<u>DCAD</u>	<u>+20</u>	<u>+35</u>	<u>+50</u>	<u>Sig.</u>
Dry matter intake, lb/day	36	38	34	NS
Dry matter intake, % body weight	3.30	3.38	2.96	*
Milk, lb/day	56	53	49	*
3.5% fat correct milk, lb/day	61	56	56	*
Milk fat, %	4.1	4.0	4.3	NS
Milk protein, %	2.9	3.0	2.9	NS

NS = not significantly different, * = significantly different

The authors concluded that a DCAD between +23 and +33 is probably optimum for lactating cows in cooler weather. Sodium sesquicarbonate (a form of sodium bicarbonate) and potassium carbonate were used in this study to supply sodium and potassium. Certainly the +50 DCAD level was excessive, probably because the ration was too alkaline or unpalatable, resulting in reduced intake. Beede (2005) recommends a DCAD for lactating cows of +25 to +30.

Another recent study from France (Apper-Bossard *et al*, 2006) used DCAD levels of 0, +15, and +30 to study response to increased cations in the rations of lactating dairy cows. They fed these levels with 20 percent and 40 percent concentrate in the diet dry matter. Intake, fat-corrected milk, and milk-fat percent increased with increased DCAD, but only on the 40 percent concentrate diet. This indicates that best response would be expected on higher concentrate rations lower in forage. They speculate that the reason for this was a localized rumen buffering effect, along with the ability to maintain blood acid-base status when cows produce acid in the rumen.

The most practical sources of cations are sodium bicarbonate and potassium carbonate. Most of the time sodium bicarbonate or sodium sesquicarbonate is the first choice due to availability and cost. Sodium carbonate and potassium bicarbonate are also available but are more expensive. Salt (NaCl) provides both sodium and chlorine and does not change DCAD significantly. Usually 150 to 250 grams (0.33 to 0.55 lb) daily of sodium bicarbonate or sesquicarbonate would be desirable with corn silage-based diets and/or high concentrate intakes, especially in hot weather.

Calculation of DCAD in Rations for Lactating Cows

In order to calculate DCAD it is necessary to know the concentrations of Na, K, S, and Cl and multiply by a constant that is derived from the atomic weight.

The equation for calculation of DCAD most often used is: milliequivalents (Na + K) – (S + Cl)/100 grams dry matter.

To get the milliequivalents of each mineral: mineral, percent of dry matter/constant for mineral based on atomic weight = milliequivalents/100 grams of dry matter.

Using the 2001 NRC requirements for Na, K, S, and Cl as percent of dry matter at 100 pounds of milk per day gives:

	Required %	Constant	=	Milli-equivalents
Na	0.22%	0.023	=	+10
K	1.06%	0.039	=	+27
S	0.20%	0.016	=	-13
Cl	0.28%	0.0355	=	-8

Total cation milliequivalents/100 grams = 10 + 27 = +37

Total anion milliequivalents/100 grams = 13 + 8 = -21

Cation-anion difference = 37 – 21 = +16

Therefore, the minimal DCAD for lactating dairy cows should be around +16, but as indicated above the optimal is greater than this.

DCAD and Dry Cows

Sulfur (S) and chlorine (Cl) are sometimes added to dry-cow diets as anionic salts or hydrochloric acid to offset sodium and potassium and to stimulate a mild metabolic acidosis. This mild acidosis before lactation begins allows the cow to mobilize needed calcium during early lactation. High DCAD rations to dry cows can impede calcium mobilization.

Dry cow Na, K, S, and Cl 2001 NRC requirements and the calculated DCAD are below.

	Required %	Constant	=	Milli-equivalents
Na	0.1%	0.023	=	+4
K	0.52%	0.039	=	+13
S	0.20%	0.016	=	-13
Cl	0.15%	0.0355	=	-4

Total cation milliequivalents/100 grams = 4 + 13 = +17

Total anion milliequivalents/100 grams = 13 + 4 = -17

Cation-anion difference = 17 – 17 = 0

Manipulation of DCAD can be used to induce mild metabolic acidosis and aid in preventing milk fever at calving (NRC 2001). To do this, limiting amounts of feeds high in K and Na is critical and is important

even if anionic salts are not used. Achieving a negative DCAD would require use of anion salts such as ammonium chloride until urinary pH is reduced to 6.2 to 6.8. Hydrochloric acid (HCl) can also be used when added to feeds such as soybean meal and it is the most potent of the anionic sources. Palatability is not as big a problem with hydrochloric acid as it is with anionic salts. Hydrochloric acid is not a compound to use on the farm unless it is already an addition to another feed. Neither anionic salts nor hydrochloric acid should be fed to lactating cows and usually are limited to the last two to three weeks of the dry period.

Forages with high K levels should be avoided in dry-cow rations because high DCAD during this period can predispose cows to hypocalcaemia (low blood calcium) at calving and consequently milk fever. When forages with high potassium levels are used in dry-cow rations, it becomes difficult to add enough anionic salts to be effective because the salts are unpalatable. Dilution of the high-potassium forage with feeds containing less potassium becomes necessary. This can be done by using feeds such as corn silage for both far-off and close-up dry cow groups and limiting grass and legume hays and silages. Also, grains low in potassium can be used in most close-up groups.

Calculation of DCAD in Feeds

An example of a calculation for DCAD in a feed is as follows for soybean meal with the following mineral analysis.

	%	Constant	=	Milliequivalents
Na	0.02%	0.023	=	+1
K	2.21%	0.039	=	+57
S	0.41%	0.016	=	-26
Cl	0.08%	0.0355	=	-2

Total cation milliequivalents/100 grams = 1 + 57 = +58

Total anion milliequivalents/100 grams = 26 + 2 = -28

Cation-anion difference = 58 - 28 = +30

Beede in 2005 presented evidence from four commercial testing labs that shows chlorine values tend to be higher than published in the 2001 NRC. Below are some common feeds used in dairy rations and their mineral content from this updated database along with the calculated DCAD.

Feed	Na, %	K, %	S, %	Cl, %	DCAD
Alfalfa hay	0.14	2.4	0.28	0.59	+34
Soybean meal	0.02	2.21	0.41	0.08	+30
Grass hay	0.17	1.87	0.18	0.54	+29
Corn silage	0.04	1.09	0.11	0.27	+15
Barley grain	0.14	0.46	0.14	0.16	+5
Corn grain	0.02	0.41	0.10	0.09	+3

Remember, as the level of potassium increases so does the DCAD as long as the other minerals stay constant. A grass with 3 percent potassium would have 29 more milliequivalents than the grass above. Forages grown on fields with high levels of manure application tend to have elevated potassium levels. The table below shows the relationship of potassium to DCAD.

Forage	Na, %	K, %	S, %	Cl, %	DCAD
Grass hay 1	.17	1.5	.18	.54	+19
Grass hay 2	.17	2.0	.18	.54	+32
Grass hay 3	.17	2.5	.18	.54	+45
Grass hay 4	.17	3.0	.18	.54	+58

Important Points when Using DCAD

1. The cations (Na and K) and anions (S and Cl) should be analyzed in feeds with wet chemistry. Do not use NIR for mineral determinations.
2. Meet the requirements for Na, K, S, and Cl.
3. It is possible, in some cases, to increase DCAD to the recommended +25 to +30 range for lactating cows by reducing S. After this, DCAD can be increased by adding sodium bicarbonate, sodium sesquicarbonate, or potassium carbonate.
4. Greater cation amounts are needed for lactating cows during hot weather due to increased needs for Na (.45%), K (1.5%), and magnesium (.35%).
5. Dry cows should have low DCAD diets approaching 0 and in some cases be negative if metabolic regulation is attempted with the use of anionic salts or hydrochloric acid during dry period transition. High-K forages will have to be limited or eliminated from rations to do this. Urinary pH between 6.2 and 6.8 indicates the effectiveness of anion sources and should be used as the criterion for effective inclusion amounts.

Literature Cited

Apper-Bossard, E., Peyraud, J.L., Faverdin, P., and Meschy F. 2006. Changing Dietary Cation-Anion Difference for Dairy Cows Fed with Two Contrasting Levels of Concentrate in Diets. *Journal of Dairy Science* 88:749-760.

Beede, David K. 2005. Formulation of rations with optimal cations and anions for lactation. Tri-State Dairy Nutrition Conference, p. 93-112.

Chan, P.S., West, J.W., Bernard, J.K., and Fernandez J.M. 2005. Effects of Dietary Cation-Anion Difference on Intake, Milk Yield, and Blood Components of the Early Lactation Cow. *Journal of Dairy Science* 88:4384-4392.

National Research Council. 2001. Nutrient Requirements of Dairy Cattle. National Academy of Science, Washington D.C.