Benefits of feeding additional potassium to lactating dairy cows

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Introduction
Potassium (K) is an essential cation, which is typically included in ration formulations for dairy cows. It is recognised that minerals have a significant number of interactions and more of these are being taken into account in feeding models such as PeRT (WorkBench). Many of the interrelationships for these minerals are between Na, K and Cl, and were identified by Sanchez, Beede and Cornell (1994) in work from the University of Florida, with the majority being interactions of Na and K, although Mg is also affected.

Previous work at MLF Agresearch has produced a model, which calculates K requirements based on a fluid pool model (Evans, 1995). Fluid pools have been estimated from the metabolic body weight. The concentration of K in each pool is known to be fixed, and the turnover of each pool has also been calculated. This allows a maintenance requirement to be determined. In addition to this, the concentration of K in milk is known, and the amount of milk being produced is entered in the Animal Definition Screen, allowing a lactation requirement to be determined. Thus for a ‘typical’ cow, (680kg, 22kg DMI and 40 litres milk) the maintenance requirement is 100 g K/day, and the lactation requirement is another 95 g K/d. The concentration of K in the ration should therefore be 0.87% as the bare minimum required for the cow, typically a 20% safety margin is added to ensure that all cows within a mixed group are properly supplied with K, resulting in a 1.06% concentration in the final ration.

This model is not currently in place in PeRT (WorkBench), which has a default value of 1.00%. This value is a good estimate for most rations, as the requirements (without safety margin) do not usually exceed 1.00%, as the DMI tends to increase as milk yield increases (variation is from 0.65% up to 0.97% without the safety margin).

The NRC (2001) model for K calculates the requirements by assessing the endogenous loss of K per day. Thus the urinary loss is calculated as a function of bodyweight, faecal loss is a function of DMI and milk requirement is calculated as 1.5 grams/kg milk. The difference between the models is in the estimation of bioavailability of K from the feed, which NRC estimates at 90%, whilst the Agresearch model assumes 100%. It can be seen in Table 1 that the two models agree well, except in scenario 5, where the Agresearch model is lower than the NRC. This is due to the high DMI for relatively small milk yield. As indicated above, the concentration of K currently defaults to 1.00% as a minimum, and thus would agree with the NRC estimate.

Based on these data, the recommended concentration of K in dairy cow feeds should be between 1.0 and 1.2% in thermoneutral conditions.
The need for additional K
Amongst the factors affecting K requirements is the physiological response of the cow to environmental conditions, specifically heat stress. Due to the excess loss of K in sweat, the K requirements of lactating cows under heat stress are higher, and 0.5% supplementary K (as inorganic or organic K) is recommended by Agresearch.

Research conducted in Texas and Idaho indicated a linear response to dietary K during Summer months at up to 2.1% dietary K (West et al, 1986, West et al, 1987a,b, Griffel et al, 1997), supplying the extra K as K$_2$CO$_3$. Sanchez, Beede and Cornell (1994) reported that milk fat percentage was maximised at 0.60% Na, 1.34% K and 0.69% Cl whilst at the same time showing a significant benefit in DMI by feeding additional K. Additional research in Israel (Silanikove et al 1998) indicated that the typical regime for feeding non-heat stressed cows was inadequate for providing Na, K and Cl to heat stressed animals in early lactation. This evidence supports the position that additional levels of K during heat stress will improve feed intake, and maintain a good electrolyte balance in the cow.

The case against additional K
When cows are not subject to heat stress, a variety of responses to feeding additional (inorganic) K have been observed. A Canadian study (British Columbia) (Fisher et al 1994) used diets with 1.6, 3.1 and 4.6% K, and showed no significant differences between DMI (23.0, 23.82, and 22.3 kg/day respectively). They also noted that increasing K in the diet increased water consumption and urine output, which has major implications for waste management. Another experiment in Florida (Sanchez et al 1994) indicated that there may be problems in feeding excess cations “was one odd treatment (a low Cl, high K, and high Na treatment combination) that may have caused a Cl deficiency” (Sanchez 2000). This may also be an explanation of the findings of Tucker and Hogue (1990) where DMI was significantly reduced by the inclusion of NaCl in the diets. The change to KCl recovered some of this decrease, but did not reach the control level. The KCl-fed cows in this study also had lower milk fat percentage than NaCl-fed cows, but there were no differences in milk yield.

Table 1. Comparison of Agresearch and NRC models for [K] using six scenarios.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agresearch Model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body weight, kg</td>
<td>650</td>
<td>680</td>
<td>680</td>
<td>600</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>Milk, kg</td>
<td>40</td>
<td>40</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>50</td>
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<tr>
<td>DMI, kg</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>[K] No safety margin</td>
<td>0.95</td>
<td>0.97</td>
<td>0.85</td>
<td>0.8</td>
<td>0.69</td>
<td>0.89</td>
</tr>
<tr>
<td>[K]</td>
<td>1.14</td>
<td>1.16</td>
<td>1.02</td>
<td>0.96</td>
<td>0.83</td>
<td>1.07</td>
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<tr>
<td>Urinary, g/d</td>
<td>24.7</td>
<td>25.84</td>
<td>25.84</td>
<td>22.8</td>
<td>24.7</td>
<td>24.7</td>
</tr>
<tr>
<td>Faecal, g/d</td>
<td>122</td>
<td>122</td>
<td>122</td>
<td>122</td>
<td>146.4</td>
<td>146.4</td>
</tr>
<tr>
<td>Milk, g/d</td>
<td>60</td>
<td>60</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>75</td>
</tr>
<tr>
<td>Total, g/d</td>
<td>206.7</td>
<td>207.84</td>
<td>192.84</td>
<td>189.8</td>
<td>216.1</td>
<td>246.1</td>
</tr>
<tr>
<td>Absorption coeff</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Mineral K req., g/d</td>
<td>230</td>
<td>231</td>
<td>214</td>
<td>211</td>
<td>240</td>
<td>273</td>
</tr>
<tr>
<td>[K]</td>
<td>1.15</td>
<td>1.15</td>
<td>1.07</td>
<td>1.05</td>
<td>1.00</td>
<td>1.14</td>
</tr>
</tbody>
</table>
A review by Sanchez, McGuire and Beede (1994) indicated an effect of Cl, Ca and Mg on DMI, which was affected by season, whilst K, Ca, Mg and season caused changes in 4% FCM. A finding borne out by Block (1994) who determined that a combination of Na and K yielded the best response in DMI and milk production. In the study by West et al (1992), the source of cation (Na or K) used to manipulate DCAD also was compared. In these mid-lactation cows, no difference between Na and K was observed.

Schonewille et al (2000) indicated a negative effect of increasing K concentration in the rations, when they used this as a model to test hypomagnesaemic tetany in cows. Although they failed to cause clinical tetany, the acute change of cows from a low to a high K ration showed a decrease of up to 21% of Mg concentration in blood, with a similar decrease in Mg excretion in the urine, indicating a large decrease in Mg absorption from the rumen. The meta-analysis work of Weiss (2004) indicated that there was a requirement for additional Mg when K concentration exceeded 1% in the diet, and an equation was proposed to calculate the additional Mg requirement.

Conclusions
- Feeding additional K in heat stress is beneficial to feed intake and thus to milk production, as well as to the health of the cow.
- Feeding additional K in a thermoneutral environment probably gives no benefit in DMI.
- Feeding additional K may cause a decrease in milk fat concentration, with no milk yield benefit.
- Increased K supplementation may inhibit Mg uptake from the rumen, and could result in hypomagnesaemic tetany.
- If K supply is increased in the diet, Mg supply must also be increased.
- Mineral interactions are complex and adding supplementary inorganic minerals to the diet is highly risky.
- Dietary K concentration should be increased by 0.5% during periods of heat stress.

References


