Neither native nor popped cornmeal in the ration of dry cows affects magnesium absorption


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Received 16 November 1998; received in revised form 19 May 1999; accepted 1 June 1999

Abstract

The hypothesis tested was that addition of starch to the ration of cows would stimulate magnesium (Mg) absorption because of a lowering of ruminal pH, which renders Mg more soluble and thus more available for transport across the epithelium of the rumen, which is the major site of Mg absorption in ruminants. The trial had a 5 × 5 Latin-square design in which five non-pregnant, non-lactating multiparous cows were fed rations containing either a mix of cellulose and maize gluten feed or native or popped cornmeal each at two levels (equivalent to 11 or 20% starch in the dry matter). The dietary periods lasted 28 days. The amount and type of dietary starch did not significantly affect total gastro-intestinal tract Mg absorption, post-prandial ruminal pH, rumen fluid concentrations of Mg, K and total volatile fatty acids; for all five treatments combined, the measured values were 5.6 ± 0.45% of intake, 6.5 ± 0.04, 0.7 ± 0.12 mmol/l, 41.0 ± 0.63 mmol/l, and 105 ± 2.3 mmol/l (means ± S.E., n = 5), respectively. For all cows and treatments combined, there was a significant, negative relationship between ruminal pH and Mg concentration in rumen fluid. The ruminal Mg concentrations were low when compared with earlier work. On the basis of published in-vitro studies showing that concentrations of soluble Mg fall to more or less constant, low values when pH values are above 6, it is suggested that the high baseline values of ruminal pH in this study, had prevented a statistically significant effect of starch intake, if any, on Mg absorption. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Magnesium; Starch; Rumen; Fermentation; Absorption

1. Introduction

Grass silages from areas with intensive livestock production are generally high in potassium (K) (Schonewille et al., 1997a). In ruminants, high K intakes inhibit magnesium (Mg) absorption which enhances the risk of hypomagnesaemia (Fontenot et al., 1989). To safeguard the Mg status of dairy cows fed grass silages rich in K, it seems more appropriate to improve Mg absorption from the diet rather than to supplement the ration with Mg because high Mg intakes by ruminants may cause a depressed nutrient utilisation (Chester-Jones et al., 1989).
In a study with dry goats the replacement of dietary cellulose, at a concentration of 342 g/kg dry matter, by an equal amount of native corn starch had a marked stimulatory effect on Mg absorption (Schonewille et al., 1997b). It is not known whether this observation extends to dairy cattle. In any event, the use of high amounts of starch in the ration of dairy cows entails the risk of ruminal acidosis and increases feed costs to a practically unacceptable level. Thus, to test whether consumption of corn starch raises Mg absorption in cows, we used in the present study diets that contained either 100 or 200 g starch/kg dry matter in the form of cornmeal.

A possible mechanism by which starch could increase Mg absorption is a lowering of ruminal pH which renders Mg more soluble and thus more available for transport across the epithelium of the rumen, which is the major site of Mg absorption in ruminants (Rogers and Van `t Klooster, 1969; Tomas and Potter, 1976). Native corn starch is slowly degraded by ruminal bacteria but popping of corn starch increases the rate of ruminal fermentation (Cone et al., 1989; Cone and Vlot, 1990) and may further lower ruminal pH (Malestein et al., 1988). Thus, it could be suggested that popped cornmeal enhances Mg absorption more than would native cornmeal. This suggestion was tested also in this feeding trial with dry cows.

2. Materials and methods

2.1. Animals and experimental design

Five non-pregnant, non-lactating multiparous cows (age 10.3±0.8 y; mean±S.E.), fitted with rumen cannulas, were used. The cows were of a Friesian×Holstein×Holstein–Friesian cross. During the experiment, they were housed in a stanchion barn.

The trial had a 5×5 Latin-square design and was preceded by a 14-day pre-experimental period that allowed the cows to become adapted to rations based primarily on artificially dried grass. Each experimental period lasted 28 days. The animals were randomly assigned to each sequence of feeding on the five experimental rations.

2.2. Rations

During the pre-experimental period the daily ration of all cows consisted of 4.5 kg artificially dried grass, 0.2 kg barley straw and 2.2 kg of a commercially available concentrate containing 9.0 g Ca, 4.9 g P and 6.3 g Mg/kg. During the experimental periods, the commercial concentrate was replaced by 0.1 kg of a pelleted experimental concentrate and 2.1 kg powdered feed containing the dietary variables. The ingredient composition of the experimental rations varied.

Table 1

<table>
<thead>
<tr>
<th>Ingredient composition of the experimental rations</th>
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<tbody>
<tr>
<td>Control</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Constant components (kg/d)</td>
</tr>
<tr>
<td>Control mix (kg/d)</td>
</tr>
<tr>
<td>Native cornmeal (kg/d)</td>
</tr>
<tr>
<td>Popped cornmeal (kg/d)</td>
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</table>

a The constant components consisted of 4.5 kg of artificially dried grass (924 g dry matter/kg), 0.2 kg of barley straw (930 g of dry matter/kg), and 0.1 kg of experimental concentrate (910 g of dry matter/kg). The experimental concentrate consisted of 5.0 g of beet vinasses, 92.6 g of beetpulp, 1.4 g of MgO, and 1.0 g premix. The premix consisted of 609.4 mg of CaCO₃, 3.0 mg of CoSO₄·7H₂O, 2.1 mg of Na₂SeO₃·5H₂O, 5.3 mg of KIO₃, 30.5 mg of MnSO₄·H₂O, 27.5 mg of ZnSO₄·7H₂O, 150.0 mg of CuSO₄·5H₂O, 17.2 mg of retinylacetate (50,000 IU), 5.0 mg of cholecalciferol (200,000 IU), and 150 mg α-tocopherylacetate (150 IU).

b The control mix (917 g of dry matter/kg) consisted of 63 g of distilled water/kg, 639 g of cellulose/kg, and 298 g of maize gluten feed/kg.

c The corn meal used in this study was derived from one batch. One portion was popped and ground to pass a 3 mm sieve. The dry matter contents of the native cornmeal and the popped cornmeal were 884 g/kg and 881 g/kg, respectively and the starch contents were 652 and 668 g/kg dry matter, respectively.
tal rations is shown in Table 1. The control ration contained cellulose and maize gluten feed which was replaced by either native or popped cornmeal so as to formulate the experimental rations. In essence, this replacement involved an exchange of cellulose (Arbocel®, Internatio B.V., Rotterdam, The Netherlands) and corn starch. The native and popped cornmeal were from the same batch and were supplied by Presco International, Weert, The Netherlands. The analysed composition of the whole rations is shown in Table 2.

The animals were fed individually. On an energy basis, the rations provided approximately the requirement for maintenance. The rations were offered twice daily in two equal portions at 08:00 and 17:00 h. Feed refusals, if any, were recorded.

2.3. Collection of samples

During the last week of each experimental period, the experimental feedstuffs were sampled daily and then pooled, ground and stored in sealed jars at room temperature.

Blood samples were taken on day 21 of each experimental period. Between 16:00 and 16:30 h, before the afternoon meal, blood was sampled from the jugular vein into evacuated heparinized tubes. The blood samples were centrifuged for 10 to 15 min at approximately 2700 g, and the plasma was collected and stored at −18°C.

During the last eight days of each experimental period, urine and faeces were collected quantitatively from each cow. Urine was collected by using urinals attached to the cows with the use of leather harnesses. Urine coursed down into two vessels so that approximately 80% was collected in one vessel. The remaining urine was collected in the other vessel which contained Na-azide as a preservative. Total urine collections from each 24-h period were weighed, and 0.5% of the total urine was sampled from the preserved urine and stored at −18°C in a plastic bottle which contained 100 ml 6 M HCl. The daily faeces production of each cow was mixed thoroughly, and 3% of the wet weight was stored at −18°C. At the end of each collection period, the stored faeces fractions of each cow were combined, mixed thoroughly and sampled. The samples were dried at 60°C for four days, ground, and stored in air-dry form in sealed jars at room temperature until analysis.

On day 19, approximately 10 min prior to the morning meal, 350 ml of Cr-EDTA solution (100 g Cr-EDTA/l) was injected into the rumen as a marker for estimating the rumen volume and passage rates of the liquid phase from the rumen. Rumen liquid samples (approximately 30 ml) were taken at 07:45, 09:00, 10:00, 11:00, 13:00, 15:00 and 17:00 h. Immediately after collection, pH of ruminal fluid was recorded and the rumen liquid samples were centrifuged at room temperature at 2700 g for 15 min.

### Table 2

<table>
<thead>
<tr>
<th>Analysed composition of the experimental rations (g/kg dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Crude protein</td>
</tr>
<tr>
<td>Crude fat</td>
</tr>
<tr>
<td>Crude ash</td>
</tr>
<tr>
<td>Crude fibre</td>
</tr>
<tr>
<td>Neutral detergent fibre</td>
</tr>
<tr>
<td>Acid detergent fibre</td>
</tr>
<tr>
<td>Acid detergent lignine</td>
</tr>
<tr>
<td>Starch</td>
</tr>
<tr>
<td>Mg</td>
</tr>
<tr>
<td>K</td>
</tr>
<tr>
<td>Na</td>
</tr>
<tr>
<td>Ca</td>
</tr>
</tbody>
</table>
and the supernatant was stored in plastic tubes at 
\(-18^\circ C \). An aliquot of the supernatant from the 
rumen liquid samples taken at 07:45, 09:00, 11:00, 
13:00, 15:00 and 17:00 h was centrifuged at 20°C at 
30,000 g for 30 min and the supernatant was stored 
in plastic tubes at \(-18^\circ C \). From the rumen liquid 
samples taken at 07:45, 09:00, 11:00, 13:00, 15:00 
and 17:00 h, 2 ml non-centrifuged fluid was de-
proteinised according to the method of Bergmeyer 
(1970). After 10 min, the de-proteinised rumen 
liquid samples were centrifuged at room temperature 
at 2700 g for 15 min and the supernatant was 
collected and stored in plastic tubes at \(-18^\circ C \) until 
analysis of volatile fatty acids (VFAs).

2.4. Chemical analyses

Samples of the feedstuffs were subjected to the 
Weende analysis. Nitrogen contents were determined 
by the macro-Kjeldahl method (IDF, 1986); a factor 
of 6.25 was used to convert g of N into crude 
protein. Ether extracts of the feedstuffs were pre-
pared according to the AOAC (1984); the solvent 
was evaporated and the crude-fat residue weighed. 
The crude fibre contents of the feedstuffs were 
estimated using the Fibertec System M2 (Tecator, 
Stockholm, Sweden). The NDF, ADF and ADL 
content of the feedstuffs were estimated according to 
the methods described by Goering and Van Soest 
(1970). To determine the starch content of the 
feedstuffs, they were enzymatically treated with 
amylglucosidase from \textit{Aspergilles niger} (EC 
3.2.1.3) to hydrolyse all starch to glucose (Keppler 
and Decker, 1974). Subsequently, glucose was mea-
sured enzymatically with a test combination (Boehr-
inger Mannheim Diagnostica, Mannheim, Germany) 
and a computerised autoanalyser (Beckman 
Synchron CX Systems; Beckman, Mijdrecht, The 
Netherlands). The free glucose content of the feed-
stuffs was measured directly. Starch was calculated 
as total glucose minus free glucose. For the ex-
perimental feedstuffs, i.e., the control mix and the 
two types of cornmeal, the in-vitro rate of fer-
mentation was determined according to the method 
described by Cone et al. (1996). Prior to the de-
termination of the selected minerals in feedstuffs and 
faeces, the samples were ashed (480°C for 6 h) and 
dissolved in 15 ml 4 M HCl. Magnesium in feed-

2.5. Statistical analyses

All data were checked for normal distribution 
using the Kolmogorov–Smirnov test and then were 
subjected to analysis of variance (ANOVA) with 
animal, experimental period and dietary treatment 
as factors (Wilkinson, 1990). Rumen-liquid mineral 
data were subjected to repeated measurement analy-
eses with animal, experimental period and dietary 
treatment as factors (Wilkinson, 1990). When a 
dietary factor had a statistically significant influence, 
Bonferroni’s test was used to identify the diets that 
had different effects on the variable involved. 
Throughout, the level of statistical significance was 
pre-set at \( P < 0.05 \).

3. Results

3.1. In-vitro fermentation of the dietary variables

To check the fermentation profiles of the dietary 
variables, the control mix, native and popped cor-
meeal were incubated with a rumen culture and total
gas production was measured (Cone et al., 1996). The high rate and subsequent decline in the rate of gas production during the first hour of the incubations (Fig. 1) probably represents the degradation of the water-soluble fraction of the experimental feedstuffs (Cone et al., 1997). After 5 h of incubation, the incubation containing the popped cornmeal had the highest rate of gas production. After 10 h, the rate had fallen to approximately 20% of the peak value, but now the control mix and native cornmeal produced their peak values. After 20 h the rate of total gas production had returned to baseline values for the three feedstuffs.

3.2. Feed intake and body weight

Experimental rations were consumed completely throughout the experiment. Mean body weight at the end of the experiment was 746 kg (S.E. 16.0; n = 5), which was almost identical (P = 0.803; paired t-test) to pre-experimental values (744 kg, S.E. 14.0; n = 5).

3.3. Magnesium balance and plasma Mg

Magnesium intake was similar for all five dietary treatments (Table 3). Upon ANOVA, faecal excretion of Mg was found to be significantly affected by the factor diet (P = 0.013), but significant differences between specific rations could not be identified by Bonferroni’s t-test. Consequently, Mg absorption and urinary excretion were similar for the treatments. The dietary treatments did not affect (P = 0.205) plasma Mg. For all treatments combined, mean plasma Mg concentration was 0.80 mmol/l (S.E. 0.014; n = 5).

3.4. Rumen liquid: Mg and K concentration, pH and VFAs

Mg and K concentrations in rumen liquid, before the morning feed and also after feeding, were not significantly influenced by the dietary treatments (Table 4). Post-prandial mean Mg values were highest after feeding the rations with either 20%

Fig. 1. In-vitro gas production rates after incubation of a rumen culture with either the control mix (□), native cornmeal (●) or popped cornmeal (○).
Table 3
Magnesium balance after the feeding of the experimental rations

<table>
<thead>
<tr>
<th>Control</th>
<th>Native cornmeal</th>
<th>Popped cornmeal</th>
<th>Pooled S.E.M.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10% starch of dm</td>
<td>20% starch of dm</td>
<td>10% starch of dm</td>
<td>20% starch of dm</td>
</tr>
<tr>
<td>Intake (g/d)</td>
<td>12.6</td>
<td>12.3</td>
<td>12.1</td>
<td>12.4</td>
</tr>
<tr>
<td>Faeces (g/d)</td>
<td>11.9</td>
<td>11.8</td>
<td>11.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Absorption (g/d)</td>
<td>0.7</td>
<td>0.5</td>
<td>0.6</td>
<td>0.9</td>
</tr>
<tr>
<td>(% of intake)</td>
<td>5.6</td>
<td>4.1</td>
<td>5.3</td>
<td>6.7</td>
</tr>
<tr>
<td>Urine (g/d)</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Balance (g/d)</td>
<td>0.4</td>
<td>0.2</td>
<td>0.3</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*nd = Not determined because the cows were offered a restricted amount of feed.

Table 4
Concentrations of Mg and K in rumen liquid (mmol/l), total volatile fatty acids (VFAs in mmol/l) and ruminal pH in cows fed the experimental rations

<table>
<thead>
<tr>
<th>Control</th>
<th>Native cornmeal</th>
<th>Popped cornmeal</th>
<th>Pooled S.E.M.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10% starch of dm</td>
<td>20% starch of dm</td>
<td>10% starch of dm</td>
<td>20% starch of dm</td>
</tr>
<tr>
<td>Ruminal Mg concentration</td>
<td>0.745</td>
<td>0.32</td>
<td>0.28</td>
<td>0.45</td>
</tr>
<tr>
<td>Post prandial</td>
<td>0.49</td>
<td>0.60</td>
<td>0.96</td>
<td>0.49</td>
</tr>
<tr>
<td>Ruminal K concentration</td>
<td>0.745</td>
<td>23.3</td>
<td>23.5</td>
<td>25.3</td>
</tr>
<tr>
<td>Post prandial</td>
<td>4.20</td>
<td>41.1</td>
<td>42.0</td>
<td>38.3</td>
</tr>
<tr>
<td>Ruminal VFA concentration</td>
<td>0.745</td>
<td>93.7</td>
<td>97.6</td>
<td>95.5</td>
</tr>
<tr>
<td>Post prandial</td>
<td>105.0</td>
<td>100.9</td>
<td>102.1</td>
<td>102.3</td>
</tr>
<tr>
<td>Ruminal pH</td>
<td>0.745</td>
<td>6.73</td>
<td>6.67</td>
<td>6.71</td>
</tr>
<tr>
<td>Post prandial</td>
<td>6.49</td>
<td>6.52</td>
<td>6.52</td>
<td>6.49</td>
</tr>
</tbody>
</table>

* Post-prandial values are geometrical means for five values; i.e., these values can be considered as an estimation of the area under the curve (Wolever and Jenkins, 1986). Cows were given a restricted amount of feed at 08:00 and 17:00 h.

Values in the same row with different superscript were borderline significantly different (P < 0.10), Bonferroni test.

Native or popped cornmeal. The ruminal pH decreased significantly (P < 0.05) after feeding, irrespective of dietary treatment. Post-prandial ruminal pH was borderline significantly lower after feeding the ration with 20% popped cornmeal instead of native cornmeal.

Before the morning feed, concentrations of total VFAs were similar for all dietary treatments. After feeding, total VFA concentrations were significantly (P < 0.05) increased when either the control ration or the ration with 20% popped cornmeal was fed. The mean post-prandial concentrations of total VFAs were highest after feeding the ration with 20% popped cornmeal, but the increase versus that for the other treatments was not statistically significant. Post-prandial concentrations (mM) of total VFAs, acetate, and propionate, and the acetate-to-propionate ratio were similar (P > 0.100) for the five rations; for all treatments combined (n = 5), the mean values were 104.8 (S.E. 2.341), 72.5 (S.E. 1.648), 15.1 (S.E. 0.356) and 4.8 (S.E. 0.047), respectively. Upon ANOVA, post-prandial concentrations of butyrate in
ruminal fluid were found to be significantly affected by the factor diet ($P = 0.044$), but Bonferroni’s $t$-test did not identify specific rations that produced different values. The butyrate concentration for all treatments combined was 13.8 mM (S.E. 0.432).

3.5. Rumen volume and passage rate

Rumen volume, absolute and fractional outflow of the liquid phase were not affected ($P > 0.807$) by any dietary treatment, the combined values for all treatments ($n = 5$) being $70.1$ l (S.E. 1.4), $5.9$ l/h (S.E. 0.07) and $8.7$% / h (S.E. 0.215), respectively.

4. Discussion

In this feeding trial, Mg absorption was not significantly affected by the starch content of the ration. In studies with goats (Schonewille et al., 1997b) and sheep (Pfeffer et al., 1970; Giduck and Fontenot, 1987) rations with a starch content of at least $298$ g/kg dry matter significantly increased Mg absorption. The difference between the outcome of this study and those with goats and sheep may be caused by the difference in ruminant species used. However, it seems more obvious that the starch content of the rations used in this study was too low to exert an effect on Mg absorption, but there is some evidence that this was not the case. Wilson et al. (1969) demonstrated that plasma Mg concentration was low in Jersey cows when grazing on a tetany-prone pasture, whereas plasma Mg was maintained within the normal range when the cows were offered supplemental starch ($900$ g/day). Assuming a maximum grass intake of $2.6$ kg dry matter/100 kg live weight (CVB, 1997) and a live weight of $350$ kg, the starch content of the whole ration may have been in the order of $90$ g/kg dry matter. This calculation indicates that in our study the starch content of the experimental rations should have been high enough to stimulate Mg absorption if this were the action by which the Jersey cows studied by Wilson et al. (1969) maintained normal plasma Mg concentrations after feeding supplemental starch.

The mechanism by which starch stimulates Mg absorption in goats (Schonewille et al., 1997b) and sheep (Pfeffer et al., 1970; Giduck and Fontenot, 1987) is not yet fully understood. A possibility is that the addition of starch to the ration may stimulate Mg absorption by increasing the rate of ruminal fermentation and decreasing ruminal pH. A lowering of ruminal pH renders Mg more soluble and thus more available for transport across the epithelium of the rumen which is the major site of Mg absorption in ruminants (Rogers and Van ‘t Klooster, 1969; Tomas and Potter, 1976). The discrepancy between the outcome of our study and that of Wilson et al. (1969) might be related to a difference in starch-induced change of ruminal pH. Feed intake in our study was approximately three-times lower than that in the study of Wilson et al. (1969). The level of feed intake is negatively associated with the buffering capacity of ruminal fluid (Robinson et al., 1986). Thus, the pH-lowering effect of supplemental starch might have been greater in the study of Wilson et al. (1969) so that Mg absorption was effectively increased which in turn allowed the cows to maintain their plasma Mg values.

For all dietary treatments combined, a significant ($P = 0.009$), negative relationship was found between ruminal pH and the Mg concentration in ultracentrifuged ruminal fluid (Fig. 2). On average, the ration containing $20\%$ popped cornmeal produced the lowest pH and highest Mg concentrations (Table 4). However, the Mg concentrations were still lower than those previously found in cows (Schonewille et al., 1992), which cannot be easily explained. The Mg concentration in ultracentrifuged ruminal fluid can be determined by various factors, including Mg intake, dietary Mg source, Mg solubility and rumen outflow (Van ‘t Klooster, 1967). The observed low values might have been caused by the rumen volume, the observed volume being relatively high (Schonewille et al., unpublished results), which could relate to the straw component of the ration. The dietary Mg concentration used in this study can be considered normal while the added Mg in the form of MgO is well available (Schonewille et al., 1992). From in-vitro studies by Dalley et al. (1997) it followed that the solubility of Mg in ruminal fluid decreases abruptly when the ruminal pH has values higher than 6. Thus, the impact of ingested starch on ruminal fermentation, and consequently on lowering ruminal pH, was probably not sufficient to increase the solubility of
Mg in the rumen and thereby increase Mg absorption. This reasoning would imply that baseline values of ruminal pH are crucial as to the effect of dietary starch on Mg absorption. Furthermore, if rumen pH indeed determines Mg absorption then the rate of fermentability of the diet components other than starch, will also affect the amount of magnesium absorbed.

The level of Mg absorption found in this study can be considered very low (Schonewille et al., 1994), but comparable values have been reported earlier (Kemp et al., 1961). Based on the observed rumen volume, Mg solubility as estimated according to Dalley et al. (1997) and Mg intake per meal, the maximum rumen concentration of soluble Mg was calculated to be 1.08 mM, which more or less corresponds with the measured postprandial values. At these low Mg concentrations there will be net ruminal Mg absorption as predicted on the basis of studies by Care et al. (1984). The process of Mg transport across the apical membrane of the rumen epithelium involves two mechanisms: a K-sensitive and a K-insensitive mechanism (Leonhard et al., 1989). An increase in ruminal K concentrations is accompanied by an increase in the transmural potential difference (Martens and Blume, 1986; Martens et al., 1987) as caused by depolarisation of the apical membrane potential of rumen epithelial cells, thereby reducing the driving force for Mg uptake by these cells (Leonhard-Marek and Martens, 1996). The transport component that is insensitive to K is a carrier-mediated process that is based on exchanging one Mg ion for two H ions (Scharrer and Lutz, 1990; Martens et al., 1991). The K-insensitive component of transepithelial Mg movement may become saturated at Mg concentrations above 4 mM (Martens and Harmeyer, 1978; Martens, 1979; Care et al., 1984), whereas the K-sensitive transport component remains a function of the Mg concentration (Ram et al., 1998). In our study, the feeding of starch did not affect the Mg and K concentrations of the ultracentrifuged rumen fluid. Thus, it seems that the K-sensitive transport component was not affected by the feeding of starch. It could be suggested that

Fig. 2. Relationship between pH of ruminal fluid and Mg concentration in ultracentrifuged rumen fluid [■ control, △ native cornmeal (10%), ○ native cornmeal (20%), ● popped cornmeal (10%), ■ popped cornmeal (20%)]. Data correspond with ante- and postfeeding rumen samples (6 time points/dietary treatment) The solid line represents the regression line: $y = -1.3766x + 9.6215$ ($R^2 = 19.5\%$, $P_{\text{model,pH}} = 0.009$, $P_{\text{constant}} = 0.005$).
short-chain fatty acids produced during ruminal fermentation of dietary carbohydrates may stimulate Mg absorption by the delivery of protons to the Mg$^{2+}$/H$^+$ exchangers located in the apical membrane of the epithelium. However, total VFA concentrations were not significantly altered by the feeding of starch. Since ruminal Mg concentrations were very low in our study, both the K-sensitive and the K-insensitive transport component facilitated only low rates of ruminal Mg absorption. These considerations explain why the observed percentages of apparent Mg absorption were relatively low and why no effect of starch feeding was observed.

In conclusion, this study shows that the addition of cornmeal to the ration of dry cows did not significantly influence Mg absorption. It is suggested that the high baseline values of ruminal pH and high buffering capacity of ruminal fluid had prevented an effect of starch intake, if any, on Mg absorption.

Acknowledgements

This study was supported by the Product Board Animal Feed (Produktchap Diervoeder), The Hague, The Netherlands. Wim Lensink is thanked for his biotechnical assistance as is Jan Van Der Kuilen for chemical analysis.

References


