

Dietary cation-anion difference could enhance acid-base status of lactating dairy cows submit to a subacidosis*

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ABSTRACT

Dietary cation-anion difference (DCAD) affects animal performance (Tucker, 1988). To understand mechanisms involved, two groups of lactating fistulated cows received one of two concentrate levels (20 or 40% DM). Each group were assigned to two 3×3 Latin squares to test three DCAD (0, 150 and 300 mEq/kg DM) on performances, ruminal fluid and acid-base status. Feed intake and fat corrected milk yield were enhanced by increasing DCAD. Responses were greater with the high concentrate diet. Rumen pH and VFA were slightly affected by treatments while acid-base status was very responsive, suggesting that increasing DCAD improves performance through changes in acid-base status.

KEY WORDS: dietary cation-anion difference, acid-base status, subacidosis, lactating cows

INTRODUCTION

Increasing DCAD increases dairy cows performances (Tucker, 1988). Very few trials have been designed to examine how DCAD, described as mEq (Na + K-Cl-S)/kg diet DM, could enhance performances. One of the possible explanation is that increasing DCAD enhances acid-base status. Na is absorbed from the gastrointestinal tract in exchange for the secretion of a proton whereas Cl is often absorbed from the gastrointestinal tract in exchange for the secretion of a bicarbonate ion. Conversely, increasing DCAD may improve ruminal activity. Furthermore, because increasing the rapidly degraded starch in the diet will increase the risk of appearance of subacidosis status, the DCAD effect could be more effective in diet rich in concentrate.

The objective of this trial was then to examine the effects of DCAD on acid-base physiology in lactating dairy cows fed at two different energetic rates.

* Supported by INZO, BP19 02402 Château-Thierry Cedex

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MATERIAL AND METHODS

Experimental design

Six midlactating Holstein cows equipped with a rumen canula were assigned to two groups of three cows according to stage of lactation, body weight, intake and milk production. Each group received one of two levels of concentrate (20% DM, diet “L” or 40% DM, diet “H”) during the entire experiment. Both groups were then assigned to a 3×3 Latin square design to test three different DCAD, 0, 150 and 300 mEq/kg DM. Each period lasted 3-weeks.

Treatments

Cows were fed *ad libitum* (10% refusals) with two complete rations based on maize silage. The H diet was formulated to present a greater acidogenic risk than the first through the inclusion of wheat and barley so that the readily degradable starch was 30.1% for L and 36.6% for H.

The three different DCAD were achieved via manipulation of dietary Na and Cl. NH_4Cl was added to achieve 0 mEq/kg DN and sodium carbonate was used to achieve 300 mEq/kg DM. Sodium bicarbonate was not used to avoid the well known buffer effect of bicarbonate in the rumen. Concentrations of the other minerals were kept constant to ensure that the physiological effects observed could be attributed to the manipulation of DCAD. The six treatments, noted L0, L150, L300 and H0, H150 and H300 have composed this experiment.

Sample collection and analyses

Intake and milk production were recorded daily. Milk samples were collected during six consecutive milkings and analysed for fat content. Blood, urine and rumen fluid samples were collected on the third weeks of each period to define the acid-base status, ruminal VFA and urinary minerals composition.

Statistical analysis

Data were analysed using the general linear models procedure of SAS according to the model for a split-plot design. The model included cow, period, concentrate level, DCAD, concentrate×period and concentrate×DCAD. Contrasts were measured for DCAD and concentrate by DCAD interactions.

RESULTS AND DISCUSSION

There were no diseases during the experiment. All data were analysed. Daily feed intake increased with increasing DCAD. This response was stronger when cows were fed with diet H (+ 1.2 kg DM/d vs + 5.0 kg DM/d; P<0.05, Table 1), confirming our hypothesis. These results were originally because of the interaction. Increasing DCAD increased fat corrected milk yield (Table 1).

Table 1. Intake, FCM, rumen pH, acetate to propionate ratio and acid-base status of cows fed with different levels of concentrate and DCAD

Sample	Diet ²	DCAD ¹			ETR	ETR c	Effects		
		0	150	300			Conc	DCAD	Conc×DCAD
Feed intake	L	19.6	20.4	20.8	0.63	4.40	NS	L**	L*, Q*
kg DM/d	H	20.7	21.2	25.7					
FCM	L	29.3	32.6	33.8	1.63	15.20	NS	L*	NS
kg/d	H	29.7	31.1	37.5					
Rumen pH	L	6.12	6.39	6.28	0.110	0.123	*	NS	NS
	H	6.05	5.94	6.17					
Range of pH	L	0.66	0.61	0.81	0.359	0.406	NS	NS	NS
	H	0.96	0.91	0.88					
C ₂ /C ₃	L	2.69	2.76	3.06	1.064	1.089	NS	NS	NS
	H	2.71	1.95	2.44					
Blood pH	L	7.40	7.41	7.43	0.010	0.025	NS	L**	L*
	H	7.36	7.40	7.44					
HCO ₃	L	22.9	25.8	27.5	1.18	2.18	NS	L**	NS
mmol/l	H	21.0	23.8	26.5					
SBE ³	L	-1.43	1.40	3.00	1.16	2.28	NS	L**	NS
mmol/l	H	-3.70	-0.67	2.22					
Urinary Na	L	24.1	22.4	100.2	36.8	16.1	NS	L*	NS
mEq/l	H	13.4	25.0	98.9					
Urinary Cl	L	227.4	89.0	26.1	25.2	19.4	NS	L**	NS
mEq/l	H	209.3	120.6	56.2					
Urinary pH	L	6.59	8.32	8.46	0.350	0.841	NS	L**	NS
	H	6.42	7.57	8.42					

¹ dietary cation-anion difference, expressed as mEq/kg DM (Na + K) – (Cl + S)

² diet L: “Low concentrate”, 20% DM; Diet H: “High concentrate”, 40% DM

³ SBE means Standard Base Excess which is an indicator of alkaline stores

L: linear effect, Q: quadratic effect

†P<0.10; *P<0.05; **P<0.01

Feeding H diet decreased ruminal pH and numerically decreased the diet $C_2:C_3$ (Table 1). This indicates that the H diet increased the rate of ruminal fermentation. Increasing DCAD did not significantly affect ruminal pH, range of pH decrease during the mean and the $C_2:C_3$ ratio (Table 1). This results differ from those described when sodium bicarbonate was added to the diet (Erdman, 1988) and indicates that DCAD had only marginal effect on ruminal fermentations.

Increasing DCAD increased blood pH, bicarbonates concentration and SBE and the increase of blood pH was more important with H diet than with L diet (Table 1). These results suggest that increasing DCAD improves cows performance mainly by influencing homeostatic metabolism. Increasing DCAD increased urinary pH, urinary Na (Table 1). Decreasing DCAD increased urinary Cl. With a low DCAD, cows excreted H^+ and Cl^- in order to limit blood pH decrease, explaining the low urinary pH. In the same time, they kept Na^+ to regulate blood pH. Inversely, with increasing DCAD thus Na intake, cows excreted Na^+ .

CONCLUSIONS

Increasing DCAD enhances high producing dairy cows performances when they were fed with a high concentrate diet. Like the effect of increasing DCAD tended to be highest when cows were fed with the more acidogen diet, we can reasonably assume that increasing DCAD could be used to prevent subacidosis apparition.

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