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How Does Live Yeast Differ from Sodium Bicarbonate to Stabilize Ruminal pH in High-Yielding Dairy Cows?

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ABSTRACT

The objectives of this study were to evaluate the capacity of 2 dietary feed additives, sodium bicarbonate and live yeast *Saccharomyces cerevisiae* (strain Sc 47), in optimizing ruminal pH in dairy cows and to determine their modes of action. Three early lactating Holstein cows, fitted with ruminal cannulas, were allocated in a 3 × 3 Latin square design. They were given a total mixed ration as control diet (CD) at a daily feeding rate of 28.0 kg of dry matter (DM)/cow supplemented with 150 g/d of sodium bicarbonate (SBD) or 5 g/d of live yeast (YD) during a 21-d experimental period (14 d of diet adaptation, 4 consecutive days of measurement and sampling and 3 d of transition). The pH and redox potential (E_h) were measured from 1 h before feeding to 8 h after feeding at 1-h intervals, and samples of ruminal fluid were taken at 0, 2, 4, 6, and 8 h after feeding for the determination of volatile fatty acids and lactate concentrations. Total tract apparent digestibility of the diet was also determined. Ruminal pH fluctuated between 6.53 at feeding and 5.57 at 5 h postfeeding. Mean pH was greater with SBD (6.21) and YD (6.14) compared with CD (5.94), showing that both additives had a pH stabilization effect. The E_h varied from –88 mV at 1 h before feeding to –165 mV at 1 h after feeding. Mean E_h and Clark's Exponent (rH) were lower with YD (–149 mV and 7.31, respectively) than with SBD (–137 mV and 7.85, respectively) and CD (–115 mV and 8.05, respectively), indicating that the yeast strengthened the reducing power of the milieu. Total volatile fatty acids were greater in SBD (95.3 m*M*) and YD (99.4 m*M*) compared with CD (85.3 m*M*). Acetate concentration was greater in SBD (60.8 m*M*) and YD (59.1 m*M*) compared with CD (53.2 m*M*). Propionate concentration was greater in YD (25.8 m*M*) than in SBD (20.0 m*M*) and CD (18.0 m*M*). Butyrate remained constant between diets. Mean total lactate concentrations were 16.5, 12.2, and 5.4 m*M* for CD, SBD, and YD, respectively, with a 67% decrease with YD. Total tract organic matter digestibility was greater for YD (66.6%) compared with SBD (61.7%) and CD (62.2%). The neutral detergent fiber digestibility was greater with YD (41.6%) compared with SBD (34.3%) and CD (29.6%), whereas acid detergent fiber digestibility was greatest in YD (32.3%), intermediate in SBD (24.4%), and lowest in CD (18.1%). By inducing a lower ruminal E_h and rH, live yeast prevented accumulation of lactate and allowed better fiber digestion, whereas sodium bicarbonate seemed to act only as an exogenous buffer.
Key words: live yeast, sodium bicarbonate, ruminal pH, redox potential

INTRODUCTION

Modern feeding strategies have changed from primarily forage-based to progressively more readily fermentable carbohydrate (**RFC**) feedstuffs in dairy rations to meet the increasing milk production of high-producing animals. These practices favor the use of silages with a high acid content, low fiber diets with reduced particle size, and high levels of concentrates (Peyraud and Apper-Bossard, 2006). As a result, they can lead to the appearance of digestive disorders such as subacute ruminal acidosis (**SARA**) in dairy cattle if appropriate precautions are not taken. Excessive intake of RFC usually implies a temporal decrease in ruminal pH after feeding because of the accumulation of VFA and lactic acid in the rumen (Russell and Hino, 1985; Nocek, 1997). Under normal circumstances, the primary means to counteract acidification of the milieu is the production of saliva, which has a reliable impact on buffering capacity of the rumen (Maekawa et al., 2002) although feedstuffs have their own inherent buffering characteristics (Giger-Reverdin et al., 1999). However, in the presence of high-RFC-based diets, saliva outflow is considerably reduced causing incomplete ensalivation of feed entering the rumen (Owens et al., 1998). The limited saliva production cannot fulfill its

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buffering role and fails in preventing an important drop in ruminal pH, thereby causing SARA.

To minimize the occurrence of ruminal acidosis, dairy nutritionists usually choose to supplement dietary buffers, especially where feeding conditions include large amounts of RFC. Commonly used as an exogenous buffer, sodium bicarbonate (**SB**) is involved in the stabilization of ruminal pH in cows that can potentially suffer from ruminal acidosis (Meschy et al., 2004). This chemical feed additive is characterized by an acid dissociation constant ($pK_a = 6.25$), which is close to the normal rumen pH. Therefore, SB is generally recognized as an efficient buffer because of its high acid-consuming capacity in the rumen, and its mode of action is well documented (Erdman, 1988; Russell and Chow, 1993).

For the last 2 decades, the utilization of new feed additives such as the probiotic yeast *Saccharomyces cerevisiae* has gained considerable interest. According to some researchers (Williams et al., 1991), positive production responses were accompanied by stabilization of ruminal pH often attributed to the lack of accumulation of lactate in the rumen thus preventing ruminal acidosis. To gain better insight into the mode of action of live yeast on ruminal fermentation, Mathieu et al. (1996) and Chaucheyras-Durand and Fonty (2002) went a step further by measuring another ruminal physicochemical parameter, the redox potential ($\mathbf{E_h}$). By integrating E_h and pH in the Nernst equation, the Clark's Exponent (**rH**) can be calculated, thereby providing a different view of the mechanisms involved in the stabilization of ruminal pH. To our knowledge, no E_h data were recorded in studies dealing with SB-supplemented diets for ruminants. Furthermore, only few references relative to the comparison of SB and the probiotic yeast are available (Quigley et al., 1992; Galip, 2006). Consequently, the objectives of this study were to observe and compare the effects of a chemical buffering substance and a live microbial additive on 1) the rumen physicochemical measurements and calculation (pH, E_h, and rH), 2) the rumen fermentation profile, and 3) the total tract apparent digestibility of the diet, to acquire a better understanding of the mechanisms of action involved in the stabilization of ruminal pH.

MATERIALS AND METHODS

Animals, Experimental Design, and Diets

Three early-lactating Holstein cows (mean milk production of 45 kg/d per cow) fitted with permanent ruminal cannulas were used. Cannulation techniques provided for humane treatment of cows, adhered to locally approved procedures, and were similar to those described by Streeter et al. (1990). Cows were kept in individual pens with free access to water. They were assigned to 3 treatments: a control diet (**CD**), a sodium bicarbonate diet (**SBD**), and a yeast diet (**YD**), in a 3 × 3 Latin square design. The CD consisted of a TMR (Table 1) and was offered twice daily in equal portions at 0900 and 1700 h. During each 21-d experimental period (14 d of adaptation to the diet, 4 d of measurement, and a 3-d transition phase), the daily feeding rate was adjusted at 28.0 kg/cow on a DM basis, to avoid sorting and orts. The YD and SBD were composed of CD supplemented with 5 g of live *Saccharomyces cerevisiae* (10^{10} cfu/g of DM, BIOSAF Sc 47, Lesaffre Feed Additives, Marquette-Lez-Lille, France) or 150 g of SB, respectively. The recommended yeast and SB doses were top-dressed on the TMR during the morning meal.

Table 1. Composition of the control diet (CD) on a DM basis (%)

Item	
Ingredient	
Corn silage	51.5
Dehydrated alfalfa	5.7
Concentrate,[1] 46% CP	17.95
Concentrate,[2] 20% CP	17.95
Ground corn	6.0
Mineral vitamin mix[3]	0.90
Nutrient analysis	
DM	57.1
OM	88.3
NDF	37.8
ADF	19.9
CP	18.7
Starch	21.6
NE_L, Mcal/kg of DM	1.6

[1]On a DM basis (%): 40.1 solvent-extracted canola meal, 19.1 soybean meal, 27.5 tanned soybean meal, 3.6 sunflower meal, 3.5 urea, 3.2 corn grain, 2.0 sugarcane molasses, 0.5 salt, 0.5 trace mineral premix (15 mg/kg of Cu sulfate, 6,000 IU/kg of vitamin A, 2,000 IU/kg vitamin D_3, and 15 mg/kg of vitamin E).

[2]On a DM basis (%): 25.0 wheat bran, 20.0 solvent-extracted canola meal, 15.0 corn grain, 13.0 tanned soybean meal, 11.1 ground corn, 10.4 ground wheat, 2.1 calcium carbonate, 2.0 sugarcane molasses, 0.5 salt, 0.5 Ucx bovine flavor (Inzo, France), 0.4 trace mineral premix (15 mg/kg of Cu sulfate, 6,000 IU/kg of vitamin A, 2,000 IU/kg vitamin D_3, and 15 mg/kg of vitamin E).

[3]Containing P (40 g/kg), Ca (260 g/kg), Mg (50 g/kg), Na (120 g/kg), Zn (5 g/kg), Mn (4 g/kg), I (40 mg/kg), Co (20 mg/kg), Se (20 mg/kg), Cu (1 mg/kg), vitamin A (450,000 IU/kg), vitamin D_3 (100,000 IU/kg), and vitamin E (1.5 g/kg).

Measurements, Sampling, and Calculations

Ruminal Physicochemical Measurements. During 4 consecutive days, for each cow, ruminal pH and E_h were recorded every hour from 1 h before the morning meal (T_{-1}) to 8 h after (T_1 to T_8). The sampling device allowed continuous measurements of pH and E_h under anaerobic conditions as described by Marden et al. (2005). It consisted of a ring-shaped lead filter, covered

on both sides with a sieve cloth. The filter was placed in the ventral side of the rumen to benefit maximum ruminal contractions. Ruminal fluid was pumped out of the rumen by a peristaltic pump (Gilson, Minipuls 2, Viliers Le Bel, France) into a thermostatic vessel maintained at 39°C. This system also allowed simultaneous and representative sampling of ruminal fluid for analysis. Animals rapidly became accustomed to the instrument and ate, ruminated, and behaved normally so that measurements could be taken 1 h after introduction of the device.

The pH, E_h, and temperature measurements were carried out using 3 electrodes connected to a digital pH meter (model 713, Metrohm, Herisau, Switzerland): a glass pH electrode (combined electrode with diaphragm DG SC and with Ag-AgCl as reference), an E_h platinum electrode (Pt SC), and a platinum thermoelectrode (Pt 100 RNEA911 – Pt100).

Calculations. The E_h is a measure of the ability of a solution to accept or donate electrons and corresponds to the potential difference (mV) between a platinum electrode and a standard hydrogen electrode. Because an Ag-AgCl reference electrode was used, all measured values were corrected using the formula: $E_h = E_0 + C$, where E_0 is the potential of the platinum electrode and C is the potential of the Ag-AgCl reference electrode compared with the Standard Hydrogen Electrode (SHE); that is, +199 mV at 39°C.

The Clark's Exponent yields a true index of the reducing power in a given milieu. It is calculated by integrating both pH and E_h values in the Nernst's equation: rH = E_h (mV)/30 + 2 pH (Marounek et al., 1987).

Fermentation Parameters. For each treatment, a 10-mL ruminal fluid sample was collected at the exit of the measuring cell at 2-h intervals from the time of the morning meal to 8 h postfeeding (T_0 to T_8). Each sample was preserved by the addition of 1 mL of mercuric chloride (2% wt/vol) and frozen at –18°C for subsequent VFA and lactate determinations.

Apparent Total Tract Digestibility of Diet. On a daily basis, feed consumption was recorded and representative samplings of feed were taken from d 15 to 17. Total fecal material from each individual cow was collected from d 16 to 18; feces were removed once daily for weighing, mixing, and sampling. Fecal samples (200 g) were dried at 60°C for 48 h and ground through a 1-mm screen for subsequent DM, OM, NDF, and ADF determinations. Apparent nutrient digestibilities of the diet were calculated from the different measurements.

Chemical Analyses

The concentrations of VFA were determined using the gas chromatographic method of Playne (1985) modified as follows: the ruminal samples were first centrifuged at 4,000 × *g* for 20 min to separate the liquid phase. For protein removal, 1 mL of supernatant was mixed with 200 μL of 25% metaphosphoric acid and further centrifuged at 20,000 × *g* for 15 min. One milliliter of supernatant was added to 200 μL (1% vol/vol) of 4-methylvaleric acid as internal standard, and 1 μL of the mixture was then injected into a gas chromatograph (Model 5890 Series II equipped with a flame-ionization detector, Hewlett-Packard, Avondale, PA).

Total lactate (DL-lactate) was determined using a commercial kit (cat. no. 11 112 821 035, Boehringer Mannheim/R-Biopharm, St. Didier au Mont d'Or, France). Dry matter and OM content of samples were determined by oven drying at 104°C for 24 h (48 h for feces) and by ashing at 550°C for 12 h, respectively. The NDF and ADF contents were sequentially determined using a Fibertec apparatus (Velp Scientifica, Usmate, Italy) according to the method described by Van Soest et al. (1991) and corrected for ash content. Fifty microliters of heat stable α-amylase (A3306, Sigma-Aldrich Chimie, Saint Quentin Fallavier, France) was used for NDF analyses and sodium sulfite was not used.

Statistical Analyses

All data were analyzed using the SPSS software (SPSS Version 13.0 for Windows, SPSS Inc., Chicago, IL) and were reported as mean values with standard error of the mean. Responses of pH, E_h, rH, total and individual VFA concentrations, and lactate contents were analyzed using a repeated-measures model that included as main plot the effects of cow, treatment, and period whereas sampling time and the interaction between treatment and sampling time were considered in the subplot, using the following model:

$$Y_{ijkl} = \mu + P_i + C_j + Trt_k + t_l + (Trt \times t)_{kl} + \varepsilon_{ijkl},$$

where Y is the dependent variable, μ the overall mean, P_i the period effect, C_j the cow effect, Trt_k the treatment effect, t_l the sampling time effect, $(Trt \times t)_{kl}$ the interaction between treatment and sampling time, and ε_{ijkl} the residual error. Differences between treatment effects were assessed by pairwise comparisons (Tukey's test).

Data for digestibility were analyzed with a GLM model including the effects of treatment, period and cow. The model used was:

$$Y_{ijk} = \mu + P_i + C_j + Trt_k + \varepsilon_{ijk},$$

where Y is the dependent variable, μ the overall mean, P_i the period effect, C_j the cow effect, Trt_k the treat-

Table 2. Effect of live yeast and sodium bicarbonate on ruminal physicochemical and fermentation parameters

	Treatment[2]				*P*-value[3]		
Item[1]	CD	SBD	YD	SEM	Trt	t	Trt × t
pH	5.94[b]	6.21[a]	6.14[a]	0.02	0.03	<0.001	0.04
E_h, mV	−115[a]	−137[b]	−149[c]	5.3	0.04	<0.001	0.01
rH	8.05[a]	7.85[a]	7.31[b]	0.13	0.02	<0.001	0.05

[a–c]Means within a row with different superscripts differ ($P < 0.05$).

[1]E_h = redox potential; rH = Clark's Exponent.

[2]Treatments: CD = control diet; SBD = CD + 150 g/d sodium bicarbonate; YD = CD + 5 g/d of live yeast (Sc 47).

[3]Trt = treatment effect; t = time effect; Trt × t = treatment time interaction effect.

ment effect, and ε_{ijkl} the residual error. Differences between treatment effects were assessed by pairwise comparisons (Tukey's test). Differences were considered significant at $P < 0.05$ and trends were discussed at $P < 0.10$.

RESULTS

Ruminal pH

The ruminal pH in animals fed CD varied between 6.41 and 5.57 (Figure 1a) with a mean pH of 5.94. With YD, the pH reached a peak at 6.53 and a nadir value of 5.90, with a mean of 6.14. With SBD, the pH fluctuated between 6.51 and 5.94 with a mean value of 6.21. Differences ($P = 0.03$) were observed between the mean pH values obtained with YD and SBD diets when compared with CD. A treatment × time interaction from T_3 to T_8 was recorded (Table 2). No significant effect was found between YD and SBD. When considering all 3 diets, the evolution of the pH curves showed a similar trend with a decrease at 1 h postfeeding (T_1) that lasted for the following 4-h period to T_5. Beyond 5 h postfeeding and until the end of the measuring period, pH values remained below 6 for CD, whereas with YD and SBD, the pH values gradually returned to their initial values.

Ruminal Redox Potential and rH

The redox potential of the ruminal fluid varied between −88 and −134 mV with a mean value of −115 mV for CD, between −102 and −155 mV with a mean of −137 mV for SBD, and between −109 and −165 mV with a mean of −149 mV for YD. The different trends of the curves (Figure 1b) were due to a significant treatment × time interaction between T_3 and T_8. The mean E_h values of all diets differed (Table 2). When compared with CD, the decrease in rumen E_h was more pronounced in YD than in SBD (34 vs. 22 mV, respectively). The calculated mean rH was lower in YD (7.31) compared with CD (8.05) and SBD (7.85).

Ruminal VFA and Lactate Concentrations

Total VFA concentrations were on average 53.2 m*M* for CD, 60.8 m*M* for SBD, and 59.1 m*M* for YD (Table 3). Treatments SBD and YD resulted in greater total VFA concentrations than CD. Mean acetate concentration was greater in SBD (60.8 m*M*) and YD (59.1 m*M*) than in CD (53.2 m*M*) from T_4 to T_8. Mean propionate concentration was greater in YD (25.8 m*M*) compared with CD (18.0 m*M*) and SBD (20.0 m*M*). From T_0 to T_8, propionate concentration was greater in YD than in SBD and CD. A significant treatment × time interaction was observed for acetate and propionate, respectively. Butyrate concentrations did not differ among treatments. The total lactate concentrations ranged from 4.9 to 32.0 m*M* in CD, from 3.0 to 30.1 m*M* in SBD, and from 1.1 to 11.9 m*M* in YD. The average concentration in YD (5.40 m*M*) was lower than in CD (16.5 m*M*) and SBD (12.2 m*M*). A significant treatment × time interaction was recorded for total lactate concentration.

Apparent Total Tract Digestibility

The apparent DM and OM digestibilities of the 3 diets were similar. There was no more than a trend ($P = 0.09$) for the advantage of YD compared with SBD or CD. Total tract NDF digestibility was greater in YD compared with SBD and CD (Table 4). Total tract ADF digestibility in YD and SBD were greater than in CD.

DISCUSSION

The high-yielding cows used in this trial were fed a concentrate diet and the large amount of RFC fermented in the rumen was expected to favor SARA. In fact, CD induced a ruminal pH below the threshold value of 6 from 3 h postfeeding until the end of the measuring

period. These observations reflected an acidotic state of the animals according to Sauvant et al. (1999). It must be pointed out that pH measurements were recorded in our trial 1 h before the morning meal to 8 h after feeding. Therefore, the initial pH value at T_{-1} was obviously not reached at T_8 because the 9-h measuring period reflected only a short part of the diurnal pattern of pH variations occurring in the rumen. Mackie et al. (1978) in sheep and Oetzel (2000) in cows reported that an 8-h interval between 2 meals did not allow the ruminal pH to return to its original value, and that the initial pH was only recovered after the nocturnal 16-h interval.

Incorporating live yeast or SB in the CD resulted in a significant stabilization of ruminal pH. These observations were in accordance with those of Fiems et al. (1993) and Erdman (1988) for live yeast and SB supplementation, respectively. Generally, in a diet containing a high proportion of RFC, a pH decrease is systematically associated with an increase in VFA and lactate concentrations (Patra et al., 1996). In the present study, the greater pH observed in YD and SBD was associated with an increase in total VFA concentrations. Live yeast supplementation led to a significant decrease in ruminal lactate contents but SB addition had no effect. As a consequence, the stabilization of pH observed with YD could also have been due to a decrease in ruminal lactate concentration. On the contrary, the stabilization of pH with SBD was not associ-

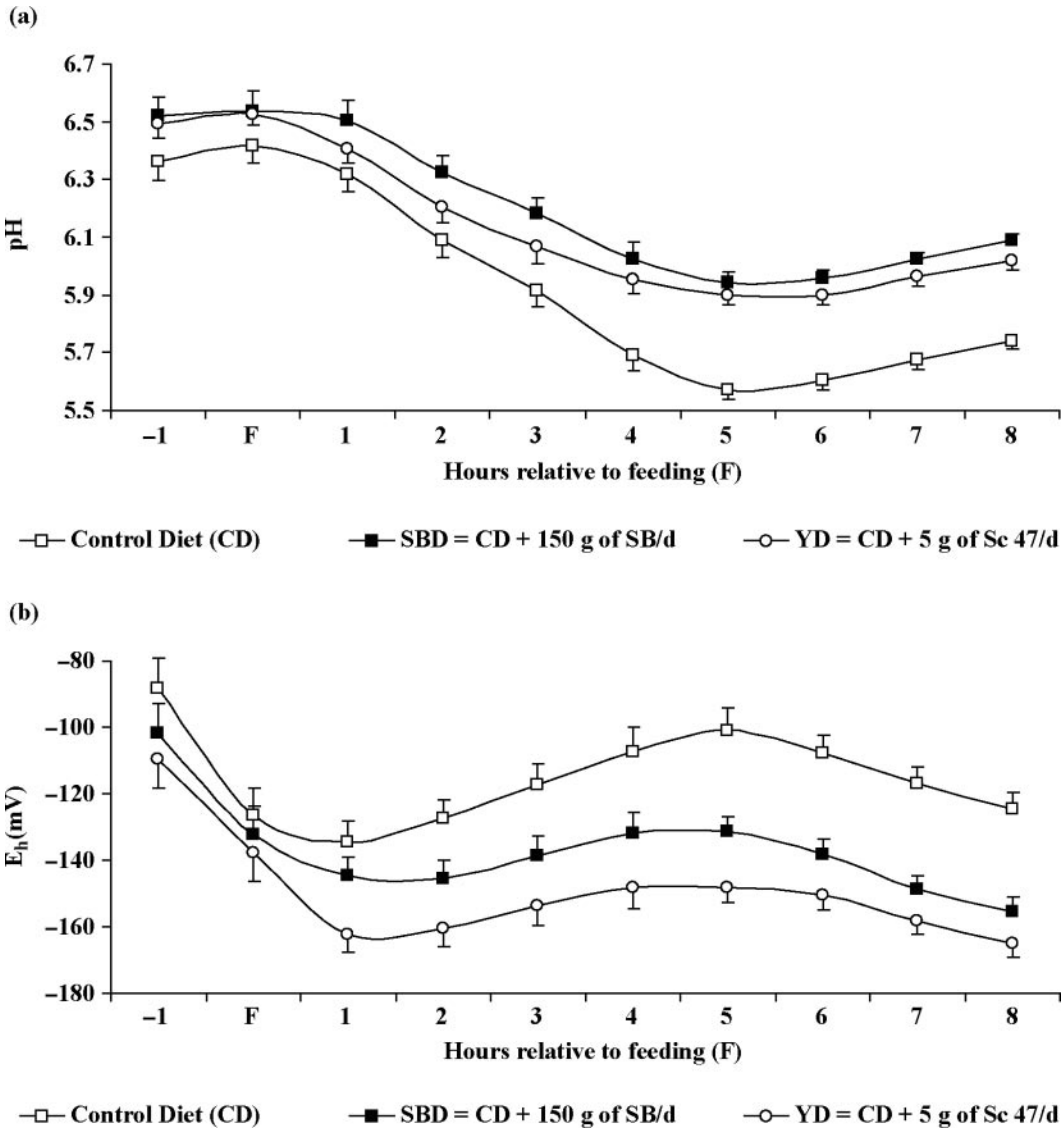

Figure 1. Effect of live yeast and sodium bicarbonate on the evolution of ruminal pH and redox potential (E_h). Vertical bars show SE.

Table 3. Effects of live yeast, sodium bicarbonate, and sampling time on ruminal VFA and lactate concentrations

	Treatment[1]				*P*-value[2]		
Item	CD	SBD	YD	SEM	Trt	t	Trt × t
Total VFA, m*M*	85.3[b]	95.3[a]	99.4[a]	1.5	0.04	<0.001	0.33
Acetate, m*M*							
0 h	39.4	46.1	45.3				
2 h	55.7[b]	59.9[ab]	61.7[a]				
4 h	57.2[c]	66.4[a]	61.9[b]				
6 h	57.4[b]	66.7[a]	64.5[a]				
8 h	56.1[b]	64.7[a]	62.2[a]				
Mean	53.2[b]	60.8[a]	59.1[a]	0.99	0.03	<0.001	0.04
Propionate, m*M*							
0 h	12.5[c]	14.3[b]	17.0[a]				
2 h	18.9[b]	19.8[b]	23.7[a]				
4 h	20.1[c]	22.6[b]	29.0[a]				
6 h	20.4[b]	22.2[b]	31.0[a]				
8 h	18.0[b]	20.9[b]	28.5[a]				
Mean	18.0[b]	20.0[b]	25.8[a]	0.49	<0.01	<0.001	0.02
Butyrate, m*M*							
0 h	6.8	6.7	5.8				
2 h	10.6[a]	8.7[b]	10.4[a]				
4 h	11.9	11.2	11.3				
6 h	11.8	12.5	12.5				
8 h	11.8	11.5	11.0				
Mean	10.6	10.1	10.2	0.25	0.35	0.14	0.48
Total lactate, m*M*							
0 h	8.7[a]	4.8[ab]	1.1[b]				
2 h	32.0[a]	30.1[a]	11.9[b]				
4 h	26.0[a]	14.5[b]	5.9[b]				
6 h	10.9	8.5	6.3				
8 h	4.9[a]	3.0[ab]	1.6[b]				
Mean	16.5[a]	12.2[a]	5.4[b]	1.6	0.03	<0.001	0.05

[a–c]Means within a row with different superscripts differ ($P < 0.05$).

[1]Treatments: CD = control diet; SBD = CD + 150 g/d sodium bicarbonate; YD = CD + 5 g/d of live yeast (Sc 47).

[2]Trt = treatment effect; t = time effect; Trt × t = treatment time interaction effect.

ated with a lower lactate concentration. Therefore, SB may have stabilized the pH through its strong capacity to neutralize protons (Le Ruyet and Tucker, 1992).

Propionate concentration did not differ between CD and SBD. In contrast, it increased in YD, in agreement with Chademana and Offer (1990). Ruminal lactate concentration decreased, thereby confirming previous studies (Williams et al., 1991). With YD, the increase in propionate and decrease lactate concentrations seemed to reveal an enhanced conversion of lactate to propionate. The greater pK_a of propionate (4.87) compared with lactate (3.86) can therefore account for the observed ruminal pH stabilization.

Ruminal pH plays an important role in regulating the microbial ecosystem, especially for low-pH sensitive microorganisms such as cellulolytic bacteria

Table 4. Effect of live yeast and sodium bicarbonate on apparent total tract digestibility of the diet

	Treatment[1]				
Apparent digestibility (%)	CD	SBD	YD	SEM	*P*-value, Trt[2]
DM	59.0	58.5	64.0	1.8	0.09
OM	62.2	61.7	66.6	2.3	0.09
NDF	29.6[b]	34.3[b]	41.6[a]	2.6	0.03
ADF	18.1[c]	24.4[b]	32.3[a]	2.9	0.01

[a–c]Means within a row with different superscripts differ ($P < 0.05$).

[1]Treatments: CD = control diet; SBD = CD + 150 g/d sodium bicarbonate; YD = CD + 5 g/d of live yeast (Sc 47).

[2]Trt = treatment effect.

(Russell and Wilson, 1996). Although ruminal pH was stabilized with both supplements, the apparent fiber digestibility data suggest that YD favored the activity of cellulolytic bacteria. The lower NDF and ADF digestibility in SBD agrees with Mould and Orskov (1983) who indicated that buffering of pH with bicarbonate only partially restored ruminal cellulolysis in sheep fed a high-concentrate diet. Offer (1990) also reported that ruminal pH was not the sole parameter to affect bacterial activity.

Measurements of ruminal E_h are seldom reported in field or experimental conditions because of their high anaerobic requirements (Marden et al., 2005). Initially investigated in the rumen by Broberg (1958), E_h measurement and rH reflect the oxidizing or reducing state of a milieu with lower values indicating more reducing conditions. According to Barry et al. (1977), E_h varied in sheep from –150 to –260 mV during the feeding cycle with more reducing values at feeding and greater values postfeeding. The rH ranged from 6.3 to 8.6 in goat's rumen fluid (Marounek et al., 1982). In this trial, the E_h shifted to more negative values and the rH decreased more with YD compared with SBD. Because only few data are available concerning the effect of live yeast on ruminal E_h and rH, comparison with the literature is difficult. The recorded E_h appeared to be in agreement with those of Mathieu et al. (1996) who also observed a more reducing ruminal environment when sheep were fed a yeast-supplemented diet. The ability of the live yeast to strengthen the reducing power of the ruminal milieu could explain the already reported improvement in growth and activity of lactate-consuming (Rossi et al., 1995) and cellulolytic bacterial populations (Chaucheyras et al., 1997). In doing so, the probiotic yeast supplement led to the stabilization of pH by the conversion of lactate to propionate and enhanced fiber digestion. In contrast, the reducing ruminal conditions reached with SBD provide no clear effect on lactate-utilizing bacteria.

CONCLUSIONS

This study allowed differentiating between the modes of action of 2 dietary additives used when dairy cows are subjected to SARA. Supplementation with bicarbonate and live yeast had the same ability to stabilize ruminal pH after feeding. Sodium bicarbonate had smaller effects than live yeast on ruminal E_h and rH, fermentation, and total tract digestibility, suggesting therefore that its main mode of action was to buffer excess acid in the rumen. Live yeast prevented the accumulation of lactate and allowed better fiber digestion by strengthening reducing conditions of ruminal environment.

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