Influence of Organic Acids on Microbial Protein Synthesis in the Rumen

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Story in Brief

The influence of added acids (1.9 percent lactic and two percent acetic) on microbial protein synthesis was studied using four Angus steers (1150 lb) with ruminal and duodenal cannulas fed a concentrate diet. Average ruminal pH values obtained with each diet were only slightly reduced (6.27 vs 6.36) by addition of a total of 3.9 percent of these acids to the diet. No effects on digestibility of organic matter (OM) or nitrogen (N) in the rumen or total tract were apparent. Efficiency of microbial protein synthesis (range: 7.6 to 11.8 g N/kg OM truly digested in the rumen) was not altered by acid addition or differences between animals (pH from 5.9 to 6.7). A slight increase in ruminal digestion of organic matter (three percent) was observed at the higher ruminal ammonia levels.

A compilation of data from this and another related study indicated that at extremes in ruminal pH, ruminal organic matter digestion was depressed but efficiency of microbial protein synthesis tended to remain relatively unchanged. Altering ruminal pH up or down from 6.3 with a high concentrate diet may adversely affect ruminal OM digestion but has little influence on efficiency of microbial protein synthesis. Ruminal residence time of particles and dilution rate of liquids may be involved.

Introduction

Ruminal pH influences ruminal fiber digestion, production of volatile fatty acids and protein solubility. These appear related to competition among microbial species, alterations in microbial metabolism or slight changes in the chemical nature of the feedstuff. Little information is available on the effect of ruminal pH on efficiency of synthesis of microbial protein. It is difficult to change ruminal pH while holding other ruminal conditions constant. The objective of this study was to determine how added acids influence ruminal pH, organic matter digestion and efficiency of microbial protein synthesis in the rumen.

Materials and Methods

Four Angus steers (1150 lb) with ruminal and duodenal cannulas were fed a ground corn diet supplemented with nitrogen from urea or ammonium acetate (NH_4AC; Table 1) to alter ruminal pH while maintaining constant ruminal ammonia concentrations. Lactic acid also was added to the NH_4AC

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Table 1. Ration composition

Item	Diets	
	Urea	NH_4AC
	—% of diet DM—	
Ground corn	44.7	46.7
Cottonseed hulls	15.2	15.2
Molasses	.46	.46
Chromic oxide	.20	.20
Supplement	39.4	37.4
Urea	1.04	--
Ammonium acetate	--	2.75
Lactic acid	--	1.90
Ground corn	35.46	30.0
Dicalcium phosphate	.53	.50
Limestone	.91	.86
Trace mineralized salt	.45	.43
Na_2SO_4	.45	.43
KCl	.54	.51
Vitamin A	.009	.008
Vitamin D	.002	.002
Crude protein, % of DM	12.1	12.7

diet to suppress pH. Two animals were fed each diet every six hrs at a daily level equal to 1.1 percent of body weight. The animals were then switched to the other diet for study.

After animals had consumed their diets for five days, fecal and duodenal samples were collected twice daily (am and pm) for three days and analyzed for organic matter, nitrogen and total purines, an index of microbial protein. On the fourth day of sampling, rumen fluid was collected for ammonia and pH measurement and determination of purine to nitrogen ratio in isolated bacteria.

Results and Discussion

Although individual ruminal pH values between animals on diets differed, (5.9 to 6.7), the average ruminal pH from each diet was similar (Table 2). Addition of three percent acid to the diet caused only a slight pH change, illustrating the strong buffering capacity of ruminal contents. Added acids had little effect on ruminal or total tract digestibility of organic matter, (Table 3),

Table 2. Ruminal parameters

	Diets	
	Urea	NH_4AC
Ammonia-N, mg/dl	14.3	16.9
pH	6.36	6.27

Table 3. Organic matter

Item	Diets	
	Urea	NH_4AC
Intake, g/day	5564	5543
Leaving abomasum, g/day		
Total	2272	2264
Non-microbial	1719	1620
Chyme, liter/day	35.0	38.2
Ruminal digestion, %		
Unadjusted	59.1	59.1
Adjusted[a]	69.0	70.8
Ruminal digestion, % of total	70.9	69.6
Feces, g/day	920	841
Postruminal digestion, % of input	59.5	62.3
Total tract digestion, %	83.4	84.8

[a]Adjusted for microbial organic matter.

Table 4. Nitrogen

Item	Diets	
	Urea	NH_4AC
Intake, g/day	114[b]	118[a]
Leaving abomasum, g/day		
Total N	85	84
Microbial N	34	36
Nonammonia, nonmicrobial	43[a]	41[b]
Ruminal digestion, %		
Unadjusted	25.9	28.6
Adjusted[c]	62.1[b]	65.8[a]
Microbial efficiency, g microbial N/kg OM truly digested in rumen	8.8	9.1
Ruminal digestion, % of total	34.7	37.2
Feces, g/day	29	27
Postruminal digestion, % of input	65.7	67.8
Total tract digestion, %	74.6	77.0

[ab]Means in a row with different superscripts differ statistically ($P < .05$).
[c]Adjusted for microbial and ammonia nitrogen.

protein (Table 4) or on efficiency of microbial protein synthesis (Table 4). Detailed study of individual pH values failed to illustrate an influence of ruminal pH on these factors.

Ruminal ammonia concentrations, while similar for the two diets (Table 2), varied from 6.6 to 22 mg/dl rumen fluid in the experiment. Levels are above those suggested to meet the needs for microbial protein synthesis (Weakley and Owens, 1983). However, in this study efficiency of microbial protein synthesis was observed to increase slightly as ruminal ammonia increased from 6.6 to 22 mg/dl. The change, however, was quite small (7.6 to 11.8 g microbial N/kg OM truly digested in the rumen) and factors other than level of ammonia may be involved. A slight stimulation (three percent) in ruminal organic matter digestion also was observed at the higher ruminal ammonia concentrations.

Data from this and another related study were compiled to include observations of ruminal OM digestion and microbial efficiency over a wider range of ruminal pH (5.8 to 6.7; Figures 1 and 2). Both of these studies were conducted with high concentrate diets. Depression in ruminal OM digestion was observed at extremes in ruminal pH (Figure 1). However, efficiency of microbial protein synthesis appeared to be affected little by pH (Figure 2). This suggests that pH may be influencing residence time of solids in the rumen and liquid outflow, which would influence ruminal digestion, while affecting the bacterial metabolism very little. These results indicate a possible role for feeding buffers to maintain a ruminal pH around 6.2 to 6.4 conducive to optimum ruminal OM digestion on high concentrate diets.

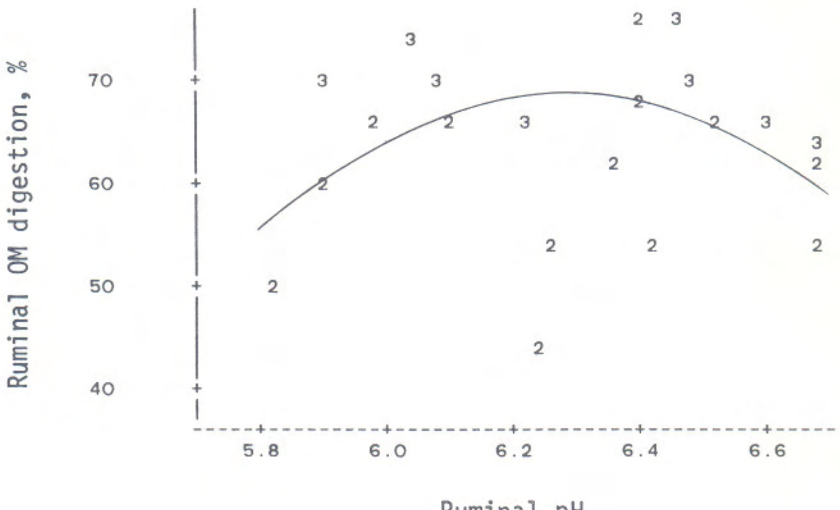

Figure 1. Influence of ruminal pH on ruminal organic matter digestion in 2 experiments[a].

[a]Quadratically related (P = .10).
[2]Data of Weakley and Owens, 1983.
[3]Data of present study.

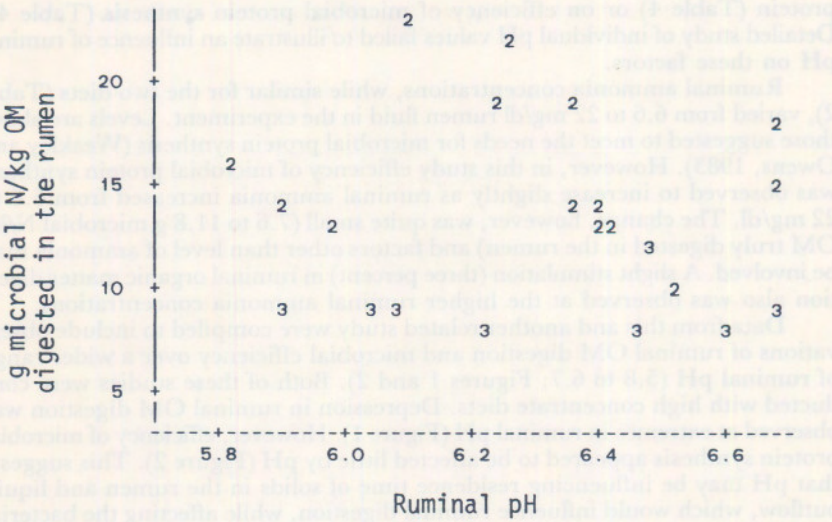

Figure 2. Influence of ruminal pH on efficiency of microbial protein synthesis in 2 experiments[a].

[a]No relationship (P>.30).
[2]Weakley and Owens, 1983.
[3]Present study.

Literature Cited

Weakley, D. C. and F. N. Owens. 1983. Okla. Agr. Exp. Sta. Res. Rep. MP-114: