Inocula Differences Affect In Vitro Fiber Digestion Kinetics

D.R. Mertens, P.J. Weimer and G.M. Waghorn

Introduction

Using digestion kinetics to estimate ruminal responses may provide information useful in formulating dairy rations. However, measurement of kinetic parameters, especially for fiber, may be sensitive to experimental conditions because differences during early fermentation (< 24 h) have a great impact on fractional digestion rates. Thus, factors which cause little difference in 48 h digestion of dry matter may have much greater impact on measurement of kinetic parameters. If digestion kinetics are to be used for feed evaluation and ration formulation, techniques must be established that give accurate and precise parameters. The objective of this project was to evaluate the effects of the animal donor and its diet on the measurement of digestion kinetics. This project was a part of a larger experiment to investigate the effects of fiber source and level on digestion and microbial ecology in the rumen.

Methods

Four cows in midlactation were used in a balanced 4 x 4 Latin square design with a factorial arrangement of treatments (2 fiber sources x 2 fiber levels). Diets containing alfalfa or corn silage, each mixed with corn, soybean meal, and minerals to obtain rations with 24 or 32% amylase-treated NDF (aNDF), were fed twice daily during the four-week periods. After three weeks, ruminal contents were collected from each cow, blended with chilled buffer to detach bacteria, and used to inoculate flasks containing either alfalfa or corn silage. The in vitro method of Goering and Van Soest (1970) was modified so fermentations were terminated after 0, 3, 5, 9, 15, 24, 30, 36, 48, 72, or 96 h. During the last week of each period, the average pH at 3 h post-feeding was also determined for each cow. At the end of the fourth week, a second in vitro trial was conducted with the pH of the in vitro system adjusted to reflect the pH of the donor animal. Kinetic parameters were determined for a single first-order model with discrete lag time using nonlinear regression.

Discussion

Ruminal pH differed among donors and diets. Cow 2661 had an exceptionally low pH throughout the experiment with an average prefeeding pH of only 5.8. Averaged across all cows, the lowest prefeeding pH of 5.78 and 6.14 were associated with alfalfa (AS24) and corn silage (CS24) diets, respectively, containing 24% aNDF. Alfalfa (AS32) and corn silage (CS32) rations containing 32% aNDF resulted in prefeeding pH of 6.07 and 6.30, respectively. Post-feeding ruminal pH was lowest for CS24 and highest for AS32 (Table 1). Average pH for the standard in vitro method was between 6.46 and 6.56. Average pH of the in vitro trials in which pH was adjusted to match that of the inocula donor was 5.89, 5.76, 5.61, and 5.54 for diets AS32, AS24, CS32, and CS24, respectively, which were within about 0.1 of the post-feeding pH associated with these diets (Table 1).

Digestion kinetics differed between forage sources and between in vitro system pH. In addition, both cow donor and its diet affected digestion kinetics. In general, potentially digestible aNDF decreased, fractional rate of fiber digestion decreased, and indigestible aNDF increased as the ruminal pH of the donor cow or diet decreased (Table 1). The observation that indigestible fiber is not constant across inocula indicates that this kinetic parameter is not simply an intrinsic property of the fiber, but is the result of the interaction between cell wall properties and the microbial population available for fermentation. Associated research in the larger experiment will attempt to define the microbial populations associated with each inocula.

Table 1. Differences in ruminal pH and digestion kinetics associated with donor and diet of the inocula. Data are averaged across forage source, in vitro pH, and period (n = 16).

Effects of inocula donor		Effects of inocula diet	
Post-feeding ruminal pH			
749	5.69[a]	AS32	5.78[a]
3691	5.67[a]	AS24	5.52[b]
3807	5.60[a]	CS32	5.53[b]
2661	5.23[b]	CS24	5.37[c]
Potentially digestible aNDF (% of DM)			
749	20.1[a]	AS32	21.3[a]
3691	18.9[ab]	AS24	19.2[b]
3807	18.5[ab]	CS32	17.8[bc]
2661	18.0[b]	CS24	17.2[c]
Fractional rate of digestion (/h)			
3691	0.059[a]	AS32	0.060
749	0.056[ab]	AS24	0.052
3807	0.054[ab]	CS32	0.052
2661	0.044[b]	CS24	0.048
Indigestible aNDF (% of DM)			
749	19.4[a]	AS32	18.5[a]
3691	20.4[ab]	AS24	20.3[b]
3807	20.7[ab]	CS32	21.2[bc]
2661	21.7[b]	CS24	22.2[c]
Discrete lag time (h)			
749	3.21	AS32	3.55
3691	3.60	AS24	2.99
3807	3.40	CS32	4.21
2661	3.31	CS24	2.76

[a,b,c]Values with different subscripts within a group are different at $P < .05$.

Conclusions

Digestion kinetics are a function of the intrinsic properties of feeds and the microbial population that ferments them. Differences between cows and their diets affected the digestion kinetics of alfalfa and corn silage, and the differences seemed to be associated with ruminal pH. Our results suggest that ruminal pH may play a central role in microbial ecology of the rumen and indicate that accurate modeling of ruminal pH must be a component of any dynamic model of ruminal fermentation using digestion kinetic parameters.

Reference

Goering, H.K. and P.J. Van Soest. 1970. Forage fiber analyses. USDA Handbook No 379. pp 20.