Variation in Ruminal and Milk Parameters Among Cow-Diet Combinations: Results From a Baseline Study to Relate Digestion Kinetics and Microbial Population Data

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Introduction

Despite the central importance of the ruminal microflora in the digestion of feedstuffs by ruminants, there have been no systematic studies of the quantitative relationship between particular ruminal microbial species and ruminal chemistry (e.g., pH, VFA concentrations), digestion kinetics (e.g., lag, rate, and extent of digestion) and animal performance (e.g., milk production and milk composition). As part of a larger study aimed at relating microbial populations to these parameters, we examined the variation in VFA patterns among diets in four cows that were used in an experiment for determining digestion kinetics (using both in vitro and in situ methods) and for assessing microbial populations (using oligonucleotide probes directed toward species-specific ribosomal RNA molecules).

Methods

Four multiparous mid-lactation Holstein cows were fed, in a Latin-square design, diets differing in source (corn silage or alfalfa silage) and amount (24% or 32% NDF) of fiber. Diets were offered at 12 h intervals as isonitrogenous total mixed rations in amounts that assured ad libitum intake. After adaptation to diet for 19 days, 13 samples were collected from each rumen over a 4-day period; Dacron bags containing various feedstuffs were also removed from each rumen over the 4-day period to determine in situ digestion kinetics. Samples were analyzed for pH and VFAs and were stored at -80 ^{o}C for subsequent analysis of microbial populations. VFAs were determined by HPLC. Rumen fluid was also collected at the beginning and end of the four day period and were used as inocula for determination of in vitro digestion kinetics.

Results

Cows displayed marked differences in ruminal pH determined just prior to feeding (range of means [n = 3], 5.36 to 6.49) or 3h post-feeding (range of means [n = 5], 5.04 to 5.94), but there was no significant relationship between the pre- and post-feed pH values (r^2 = .136). Despite the low pH of many of the ruminal samples, none of the 208 samples examined in this study contained significant concentrations of lactate or succinate.

Molar concentrations of ruminal VFAs (acetate, propionate, butyrate, and the sum of these acids) were remarkably constant over the 12-h feeding cycle. Individual cows displayed marked variation in the amounts and proportions of VFAs, and marked variations were observed among diets within cows as well (Fig. 1). Ruminal acetate/propionate (A/P) ratios (Fig. 2) and milkfat (Fig. 3) varied markedly among cow-diet combinations. The positive correlation (r^2 = .73) between milkfat and A/P ratio was even stronger (r^2 = .88) at high (> 100 mM) acetate concentrations. Milkfat was not correlated with concentration of acetate (r^2 =.002) or butyrate (r^2 = .07) but was negatively correlated with propionate concentrations (r^2 = .50). In general, diets based on alfalfa silage yielded higher A/P values and higher milkfat compositions than did corn silage-based diets at equivalent NDF concentrations.

Conclusions

Large, statistically-significant differences in ruminal pH, VFA profiles, and milk parameters were observed among the four cows and among diets within cows. These data will provide a valuable set for relating ruminal and milk

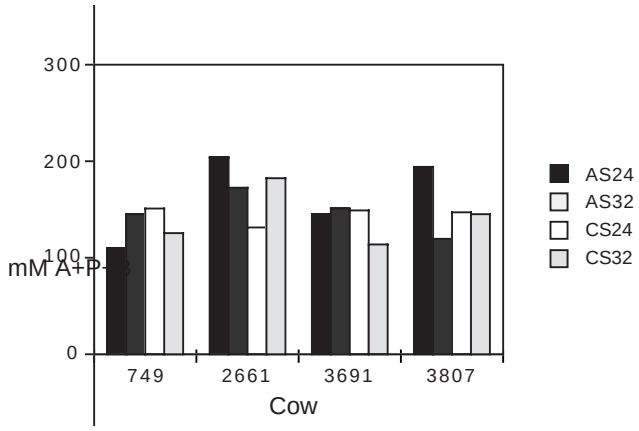

Figure 1. Mean values of the sum of the ruminal concentrations of acetate, propionate, and butyrate in four cows fed four different diets.

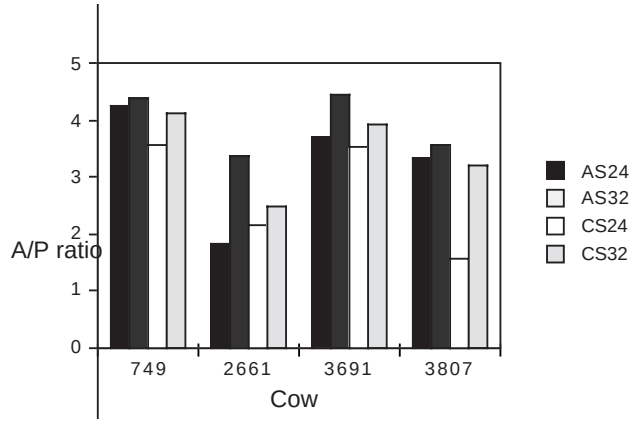

Figure 2. Mean values of ruminal acetate/propionate ratio.

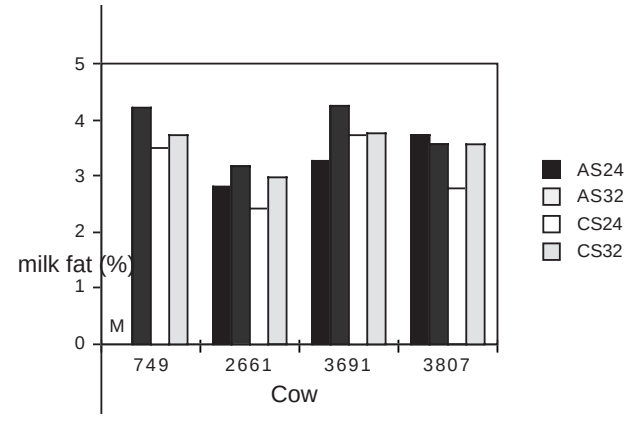

Figure 3. Mean values of fat content of milk. M indicates lack of data for cow 749 on the AS24 diet due to development of mastitis at the end of experimental period 4.

parameters to digestion kinetics and to specific populations of ruminal microorganisms, permitting a systematic determination of the relationships among ruminal chemistry, ruminal microbial populations, digestion kinetics, and animal performance.