

## Effects of Ruminal Short-chain Fatty Acids and pH on Gastrointestinal Development of Dairy Calves

### Abstract

While the importance of pH and short-chain fatty acids (SCFA) on rumen development in calves is well-known, their impact on the small and large intestines are unclear. This study investigated the effects of ruminal SCFA concentrations ([SCFA]) and pH on the performance and hindgut fermentation and development of calves. Holstein bull calves ( $n = 32$ ) were individually housed and fed 900 g/day milk replacer twice daily and calf starter and water ad libitum. At day  $10 \pm 3$  of life, the rumens were fistulated and cannulated. At day 14 of life, calves were grouped by body weight and assigned in a  $2 \times 2$  factorial arrangement of high or low [SCFA] (285 vs. 10 mM) and high or low pH (6.2 vs. 5.2), creating four treatment groups: high [SCFA], high pH (HS-HP); high [SCFA], low pH (HS-LP); low [SCFA], high pH (LS-HP); and low [SCFA], low pH (LS-LP). On days 21, 35, and 49, feces were sampled to calculate apparent total tract digestibility, determine short-chain fatty acid concentrations and pH. Then, the rumen was evacuated and washed for 4 h with one of four treatment buffers. Buffer samples were taken hourly to calculate ruminal SCFA disappearance rates. On day 49, following the rumen wash, calves were harvested, and the tissue weight and length, and digesta pH of the rumen, cecum, colon, and rectum were recorded along with the digesta pH of the duodenum, jejunum, and ileum, followed by rumen, cecum and colon tissue sampling for histomorphometric and gene expression analysis. Data were analyzed with main factors (SCFA, pH, and SCFA  $\times$  pH) as fixed effects and repeated measures for weekly measurements. Treatment and days did not affect performance parameters such as apparent total tract digestibility and gut measurements. In the duodenum, jejunum, and ileum, HS-HP had a greater digesta pH than LS-HP ( $P = 0.05$ ,  $P = 0.04$ ,  $P < 0.01$ , respectively), while the hindgut digesta pH was only affected by the [SCFA] ( $P < 0.01$ ). High [SCFA] increased the concentration

of colonic isovaleric acid ( $P = 0.05$ ) and fecal branched-chain fatty acids ( $P < 0.01$ ), while only colonic acetic acid ( $P = 0.05$ ) and fecal lactic acid concentrations ( $P < 0.01$ ) were lower in the HS-LP group. Cecum mucosal thickness tended to be greater in calves in the low pH groups ( $P = 0.07$ ) while decreasing the colonic crypt depth ( $P = 0.02$ ) and tending to decrease relative cyclin A2 expression ( $P = 0.09$ ). The high [SCFA] groups had a better cecal crypt development score ( $P = 0.03$ ), an increase in colonic cyclin A2 ( $P < 0.01$ ) and NBC1 expressions ( $P < 0.01$ ), and a tendency to increase ruminal IGF-1R expression ( $P = 0.08$ ), as well as the total ruminal SCFA disappearance rate ( $P = 0.08$ ). The HS-LP group had increased propionate ( $P = 0.05$ ) and butyrate disappearance rates ( $P = 0.05$ ). In summary, 4 h of buffer infusion in the rumen does not change calf performance but does affect hindgut fermentation and epithelium development.