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ASPECTS OF RUMEN ADAPTATION IN DAIRY CATTLE

The energy requirements of dairy cattle change rapidly around calving. During the dry period energy is required for maintenance, recovery from the previous lactation, and fetal growth. After calving, with the start milk production, energy requirements increase by a factor 3 to ~180 MJ net energy for lactation. To meet this requirement, feed intake doubles and high quality lactation rations are fed, usually containing a sizable portion of concentrate which further drives the fermentable organic matter (FOM) intake. As a result, daily volatile fatty acid (VFA) production by the rumen microbiota increases during early lactation compared with the dry period. To maintain rumen pH and prevent a negative impact on production and health, clearance of the produced VFA is essential. The capacity of the rumen for absorption of VFA is associated with the surface area and function of the papillae covering the rumen wall. However, to date, knowledge of the changes in rumen morphology and function as they occur around calving was scarce. This adaptation process was studied in detail as part of the PhD-thesis "Aspects of Rumen Adaptation in Dairy Cattle" for which two experiments were conducted using rumen cannulated Holstein Friesian cows. In the lactation experiment, the effect of transition from the dry period to the subsequent lactation, and the effect of early lactation concentrate build-up strategy on the adaptation of the rumen were studied. The concentrate build-up strategy consisted of either a rapid (1.0 kg of DM/d) or gradual (0.25 kg of DM/d) increase of concentrate allowance (up to 10.9 kg DM/d), starting at 4 d pp. In the dry period experiment, the effect of feeding supplemental concentrate (3.0 kg DM/d) during the late dry period, in order to 'prepare' the rumen for the lactation, was studied.

In the lactation experiment, intake of FOM was 5.7 kg/d during the dry period, but increasing after calving to 15.0 kg/d at 80 d postpartum (pp). The total production rate of VFA, measured using an isotope dilution technique, was affected by the changes in FOM intake, and increased 2.3 fold from 53 mol/d during the dry period to 123 mol/d during lactation. The greater FOM intake with the rapid increase in concentrate allowance at 16 d pp coincided with a 54% greater propionate production compared with a gradual increase in concentrate allowance, whereas acetate and butyrate production rate were not affected. Papillae surface area decreased 19% during the dry period to 28.0 mm2 at 3 d pp, and increased during the following early lactation to 63.0 mm2 at 80 d pp. Papillae surface area increased faster with the rapid increase in concentrate allowance and was 38, 34 and 22% larger at 16, 30, and 44 d pp respectively, than with a gradual rate of increase of concentrate allowance. During the dry period experiment, feeding concentrate during the dry period in 'preparation' for lactation did not affect daily FOM intake (6.0 kg/d) but temporarily increased VFA concentration in the rumen fluid by 21 m*M* to 121 m*M*, and increased papillae surface by 29%. However, the increased papillae surface area in the dry period was not maintained into the subsequent lactation. The postpartum development of the rumen papillae was not affected by the treatment during the dry period. The results of both experiments indicate that rumen papillae respond to changes in FOM intake and VFA production during the dry period and early lactation, and that the magnitude of this response depends on the rate of change in FOM intake.

During both experiments, the fractional absorption rate of VFA (k_aVFA) was measured using a buffer incubation technique in an empty washed rumen. During the lactation experiment, in accordance with the developments in papillae surface area, the k_aVFA decreased during the dry period with 30% to 0.34/h at 3 d pp. During the subsequent lactation, it increased rapidly to 0.56/h at 16 d pp and further to 0.72/h at 80 d pp. However, the greater papillae surface area due to the rapid increase in concentrate did not coincide with a greater k_aVFA. During the dry period experiment, k_aVFA increased after calving by 50% to 0.48/h at 45 d pp, but the increase in papillae surface area due to supplemental concentrate during the dry period neither affected the k_aVFA during the dry period (0.36/h) nor the subsequent lactation.

The results from the experiments show that morphologically and functionally the rumen papillae can adapt rapidly to the changes in FOM intake and daily VFA production associated with the transition from the dry period into the subsequent lactation. The contrast in response of rumen papillae surface area and the fractional absorption rate of VFA to the concentrate treatments indicates that papillae surface area is not the limiting factor for VFA absorption during early lactation. This proposition is further supported by the limited histological changes of the rumen epithelium and limited changes in gene expression. The data suggests that an extra-epithelial factor, probably epithelial blood flow, limits the rumens' capacity for VFA absorption. In

addition, absorption of VFA from the buffer fluid was found to be substantially more rapid than from the 'normal' rumen contents during the VFA production measurements. This suggests that the ruminal capacity for VFA absorption is not fully utilized in the natural filled rumen but likely limited by factors such as the intra-ruminal fluid dynamics responsible for transporting the VFA to the rumen wall. In conclusion, the large capacity of the dairy cow rumen to adapt to the ration changes associated with the transition period indicates that the commonly observed negative impact of low rumen fluid pH on milk production and cow health are primarily farm management and not cow related.

References

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