RESEARCH

"The Impact of Host-Microbial Interaction on Feed Efficiency of Feedlot Cattle"

IMPACT OF RUMEN MICROBES ON FEED EFFICIENCY

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Background: In the beef production system, feed costs account for 60-70% of the total costs of production. Just a 1% improvement in feed efficiency would save the feedlot sector alone an estimated $11.1 million annually.

A number of biological processes have an effect on feed efficiency including production status (growing, gestating, lactating, etc.), body composition (ratio of fat to lean), feeding patterns and behaviour, animal activity, protein turnover and other tissue metabolism, thermoregulation, and the act of digestion. Since the rumen and the microbes within play an essential role in providing energy to support these biological processes through the digestive process, the microbes themselves may be associated with their host animal's ability to be more feed efficient.

Previous research has shown that the microbial populations within the rumen are different for inefficient and efficient steers, with the efficient steers also producing significantly higher levels of butyrate and valerate volatile fatty acids. Further, the microbial populations also appeared to vary based on breed, suggesting that host genetics may play a role in determining rumen microbial structure.

Objectives: This project aimed to identify factors associated with enhanced feed efficiency in feedlot cattle, focusing specifically on the microbial populations in the rumen and any effects of host-microbe interactions on feed efficiency. The association between feed efficiency and acidosis was also investigated.

What they did: Approximately 100 steers were measured for individual feed intake using the GrowSafe™ system. Residual feed intake (RFI - a measure of feed efficiency independent from animal body size and growth rate) was measured on all animals. The ten animals with the highest RFI (low feed efficiency) and 8 animals with the lowest RFI (high feed efficiency) were then moved to the Metabolic Unit at the University of Alberta and fitted with rumen cannulas.

Trial 1: Animals were separated into two groups consisting of four low RFI (efficient) and five high RFI (inefficient), and fed the same diet throughout the experiment. Rumen contents were swapped between animals, with one high RFI animal acting as the unswapped control. Swap pairs were as follows: two low RFI steers from each group, two high RFI steers from each group, two low RFI steers from Group 1 with two high RFI steers from Group 2, and two high RFI steers from Group 1 with two low RFI steers from Group 2. Animals for each pair of rumen content swaps were chosen based on RFI (low or high) and similar body weights. After 28 days, the rumen contents were swapped back to the original host animals. Rumen content samples were taken from multiple locations in the rumen just prior to swapping and on days 1, 3, 7, 14, 21, and 28 of the first swap. After the rumen contents were returned to the original host, samples were also taken on days 28, 31, 35, 42, 49 and 56. Body weight and rumen pH were also measured prior to each swap.

Trial 2: Upon the completion of the first experiment, three steers characterized as acidosis resistant (meaning the steers spent the smallest amount of time during the day with a low rumen pH) and three steers characterized as acidosis susceptible (meaning the steers spent the largest amount of time during the day with a low rumen pH) were chosen for further evaluation of volatile fatty acid production, rumen pH, health of rumen papillae, and the rumen microbial population.

What they learned: Trial 1: The rumen microbial populations were highly adaptable. After the swap, most of the microbial populations shifted to more closely resemble the host's original population. The time it took for the populations to adapt to the new environment varied between animals, from one to four weeks. A specific microbial population of interest is the

methanogens. Previous research has shown that more efficient animals produce less methane, so changes in this microbial population are of interest. This study did not find any firm relationship between feed efficiency and methanogen populations before or after the swaps, though the total number of methanogens present did increase after the swap.

Unfortunately, RFI could not be measured during the swap periods, but feed conversion ratio (FCR) was calculated to examine effects on feed efficiency between swap pairs. The control animals (no swap, high RFI, inefficient) both exhibited the same trend in FCR, which suggests that rumen microbial population differences may be associated with changes in FCR. For the low RFI-low RFI swap pairs, the rumen content swap did not have any effect on dry matter intake (DMI) or FCR. For the high RFI-high RFI swap pairs, the swap did affect DMI and FCR, but not consistently. This may be due to more variation in RFI among the high RFI animals. For the low RFI-high RFI and high RFI-low RFI swap, when the pairs had extreme differences in RFI, introducing rumen contents from the low RFI steers to the high RFI steers improved FCR, while the contents from the high RFI steers introduced to the low RFI steers had an adverse effect on FCR. It is not clear whether these differences in FCR would persist over a longer period of time than the 28 days between swaps. Also, when original RFI measurements were not as extreme, differences in FCR could not be attributed to the rumen contents swap.

Trial 2: The three steers that were acidosis resistant were also low RFI (efficient) steers, and the three steers that were acidosis susceptible were high RFI (inefficient) steers. In addition, the microbial populations in the rumen were very different between acidosis resistant and acidosis susceptible animals, in both rumen content and rumen wall samples. The acidosis resistant steers had a total lower volatile fatty acid concentration, but higher proportion of butyrate compared to the acidosis susceptible steers. Greater gene expression of sodium hydrogen exchanger isoform 3 (NHE3) and Toll-like Receptors 2 & 4 genes was also observed in the acidosis resistant steers.

What it means: Trial 1 demonstrated that the host rumen environment can cause microbial population changes, and the time it takes for the microbial population to adapt to a new rumen environment is animal dependent. While some swap pairs showed a link between rumen microbial population changes and feed efficiency, there is no direct evidence to connect a specific microbial population to improved feed efficiency. Further research is underway to characterize which microbial populations (if any) are directly related to feed efficiency. Trial 2, although sample sizes were very small and results must be interpreted with caution, indicated that low RFI (efficient) steers might also be more resistant to acidosis. The greater expression of NHE3 in the acidosis resistant animals indicates that these animals may have a faster rate of volatile fatty acid absorption, lower volatile fatty acid production, or both. The higher expression of Toll-like Receptors 2 & 4 in acidosis resistant animals suggests a better rumen barrier function in those animals. The relationship between feed efficiency and acidosis resistance is also being explored in more detail.

Due to the complex nature of ruminant digestion, it makes sense that the microflora found in the rumen may play some role in determining an animal's level of feed efficiency. This project explored some of the complex relationships that exist between the host animals and the microbes in the rumen. Further understanding of these interactions could help producers get more out of dollars spent on feed. If more efficient animals are truly more resistant to acidosis, this could help reduce the need for acidosis and liver-abscess reducing medications, as well as improve the all around performance of feedlot cattle.

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