Doctoral Thesis

Digestive Physiological Studies on Nitrogen Utilization of Steers Fed Home-grown Feeds

(Summary)

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Overall objectives of this study were to evaluate domestic forage and grain based diets for steers in digestive physiological perspective of N and AA based on digestion, absorption and metabolism. These studies would contribute to the establishment of feeding techniques to get high level production of ruminants with domestic forage and grain diets, improve the country's low food self-sufficiency rate and prevent an excess of animal waste.

In Chapter 2, the objectives were to evaluate the effects of concentrate levels supplemented to a high-grass silage based diet on the digestion extent of nutrients in the rumen and intestine of steers, and to compare N balance with or without duodenal Met infusion. Four Holstein steers (248 ± 6 kg) fitted with ruminal and duodenal cannulas were fed Italian ryegrass silage as a single forage source at 2% of BW in DM. The levels of supplemental concentrate were 0.35 (IsCl) and 0.85% (IsCh) of BW on DM basis, respectively. Methionine (5 g/d) was continuously infused through the duodenal cannula. Four treatments were IsCl, IsCl with Met infusion, IsCh, IsCh with Met infusion, and tested in a 4×4 Latin square design. Dry matter intake of steers was higher in IsCh diet by 1 kg/d compared with in IsCl diet, as expected. Concentrate level did not affect OM digestibility in the rumen, but did in the total tract, and the digestible OM intake was greater for IsCh diet by 24% than for IsCl diet. Intake, digestion site and

extent of NDF were not different between the concentrate levels. Starch intake and digestibility for IsCh diet were higher than that for IsCl diet, and the digestible NFC in the total tracts also tended to be greater for IsCh diet. Duodenal flows of microbial N and non-ammonia N, and digestible N in the intestine were greater for IsCh than IsCl diet. Retention of N was improved by 85% for IsCh diet compared with for IsCl diet, but duodenal Met infusion significantly did not affect the N retention of steers consumed both levels of supplemental concentrate. These results suggest that additional Met delivery to the lower gut of steers fed high Italian ryegrass silage diets could not increase N retention, but a small increase of concentrate supplement is useful feeding management to improve N utilization through an increase in available energy supply for rumen microbial yield and host animal.

In Chapter 3, the experiment was carried out to evaluate the combination effects of whole crop corn (Cs) or rice (Rs) silage with steam-flaked corn (Cg) or rice (Rg) grain on ruminal carbohydrate digestion, duodenal N flow and blood plasma AA concentration in steers. Four Holstein steers (490 ± 46 kg of initial BW) fitted with ruminal and duodenal cannulas were used in a 2×2 factorial design. The four diets consisting of 37% whole crop silage and 35% steam flaked grain were fed at a level equal to 1.1 kg daily gain. Chromic oxide as an indicator of digesta flow was

administered at feeding time of 0800 and 1800 h. Dry matter intake tended to be greater for Cs diets than for Rs diets. The ruminal digestibility of starch and NFC for Rs and Rg diets compared with Cs and Cg diets was greater, but that of aNDFom was less. Because the ruminal disappearance of carbohydrate (NFC plus aNDFom) was similar across the four diets, the duodenal flow of microbial N was not affected by the silage and grain sources. However, duodenal flows of non-ammonia N and essential amino acids tended to be greater for Cs than Rs diets. There was an interaction of duodenal Met flow by silage and grain sources: greatest for CsRg and least for RsRg diet. The Met concentration in blood plasma 2 h after morning feeding was less for Rg than Cg diets. Reduction ratio of plasma amino acid concentration after feeding to before feeding was numerically greatest for Lys with CsCg, RsCg and RsRg diets, but for Leu and Met with CsRg diet. The Cs diets in comparison with the Rs diets tended to be greater in N retention because of the greater intake of digestible OM. These results suggest that whole crop silage source combined with corn or rice grain affects N use in steers through the digestible OM intake, and the kinds of limiting amino acid may differ among the combination of whole crop silage and grain sources.

Chapter 4 aimed to investigate the effects of amino acid supply to different grain sources diet on AA metabolism by visceral tissues in steers fed corn silage-based diets.

Four Holstein steers (244.6 ± 11.4 kg of initial BW) were surgically fitted with abomasal cannula and chronic indwelling catheters in the mesenteric artery, hapatic vein and portal vein and mesenteric vein. The experiment was comprised of 4 treatments: (1) corn diet with duodenal water infusion ; (2) corn diet with duodenal 10 g/d of L-Met infusion ; (3) rice diet with duodenal water infusion; (4) rice diet with duodenal 10 g/d of L-Met infusion, and was performed in a split plot crossover design. The experimental diets provided at approximately 2 times maintenance requirements of total digestible nutrients (TDN). Feed were delivered in 12 equal portions daily at 2-h intervals from an automatic feeder. The experiment was consisted of two 14 d periods with 8 days for adaptation and 6 days for infusion period. During 6-d infusion period, one steer in each dietary treatment was infused with Met foe first 3 days followed by water, whereas another steer was infused them by reverse order. The Met solution, with 10 g of L-Met resolved in 2 L of tap water daily, was continuously infused by a peristaltic pump. Net output or uptake of AA were measured across portal-drained viscera (PDV), liver, and splanchnic (PDV plus liver) tissues. Blood and plasma flows across PDV and TSP, net fluxes of AA by PDV, liver and TSP were unaffected by grain sources, indicating replacing corn grain with rice grain did not affect postruminal absorption of available N. The postruminal supply of Met resulted in a significant

increase in the amount of Met absorbed across PDV and arterial plasma concentration of Met, together with a numerical, although statistically non significant, reduction of the amount of total EAA delivered to the peripheral tissues (net TSP fluxes). These data suggest that provision of greater duodenal AA flow of Met couldn't seem to increase AA delivered to the peripheral tissues for growing ruminants consuming corn silage-based diets consisting in 35% (DM basis) steam flaked corn or steam flaked rice.

Overall, these results indicated that it is important to evaluate dietary nutrient value and supplements for ruminants in digestive physiological perspective of N and AA based on digestion, absorption and metabolism. A properly balanced supply in both energy and N components in diet is essential for an optimization of N utilization efficiency. A small increase of concentrate supplement is useful feeding management to improve N utilization through an increase in available energy supply for rumen microbial yield and host animal in growing steers fed high Italian ryegrass silage diets. The whole crop silage source affects N utilization in steers through digestible OM intake, and the kinds of limiting amino acid may differ with the combinations of silage and grain sources. Therefore, further studies are warranted to clarify the most limiting AA for ruminants fed combination diets consisting of whole crop rice silage and/or rice grain. Despite of differences in digestion characteristics between rice grain and corn

grain, replacing corn grain with rice grain did not affect postruminal absorption of available N. Provision of greater duodenal AA flow of Met could not seem to increase AA delivered to the peripheral tissues for growing ruminants consuming corn silage-based diets. Different limiting amino acids for different dietary treatment combinations should be taken into consideration and clarified when rice silage or rice grain can be used as a substitution of corn silage or corn grain for feeding animals.