Doctoral Thesis

Nutritional Studies on Utilization of Silages Based on Local-Grown Plants in Ruminants

(Summary)

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Ensiling the locally available forages, such as wild plants and by-product of tuber crops, could prolong the availability and increase the digestibility of these forages in ruminants. The evaluation of the effects of ensiling on nutrient properties and nutrient utilization in the ruminants could provide the evidences to build feeding strategies based on these forages on ruminant production. This study aimed to investigate the factors affecting nutritional properties of kudzu vine silage and nutrient utilization of sweet potato vine (SPV) silage and cassava foliage (CF) silage in ruminants.

In chapter 2, the effects of harvesting month and ensiling treatment on the nutrient contents and protein fractions of kudzu vine silage based on the Cornell Net Carbohydrate and Protein System (CNCPS) were investigated. In experiment 1, the effects of harvesting in June, August and October on chemical compositions, protein fractions and photosynthetic pigments of the ensiled kudzu vine were investigated. The results showed that the harvesting month did not affect crude protein (CP, 14-17% dry matter (DM)) content. However, the neutral detergent fiber (NDF) content was lowest, while non-fiber carbohydrate (NFC) and photosynthetic pigments were the highest for the October-cutting vine silage. Ensiling increased the A + B_1 fractions, but decreased the B_2 and B_3 fractions. As a result, the A+B_1 fraction was the highest for June- and lowest for August-cutting vine silages, while B_2 was the lowest for June- and was similar between August- and October-cutting vine silages. The B_3 and C fraction of kudzu vine silage were not affected by harvesting months. Ensiling kudzu vine harvested in October seems to be better to used as forage for ruminants. In the experiment 2, October-cutting kudzu vine was assigned into three ensiling treatments consisting untreated, wilting and formic acid (FA) addition. These silages were prepared by the pouch method and opened at 7 and 60 days of ensiling. The results showed that the elevation of A+B_1 mainly occurred during first 7 days of ensiling, while the NH_3-N mainly elevated during later period (7-60 days) of ensiling. FA treatment reduced the elevation of A+B_1 fractions and NH_3-N concentration and the decrease of B_2 and B_3 fractions both

at 7 and 60 days of ensiling. In conclusion, although the A+B_1 and B_2 fractions accounted for major portion of CP in the untreated kudzu vine silage and varied with harvesting month, it could decrease by wilting and FA treatments.

In chapter 3, the effects of ensiling treatment on chemical composition and protein fraction of CF silage and SPV silage were investigated (Experiment 3). The CF and SPV were separately assigned into three ensiling treatments consisting untreated, wilting and FA treatments. Silages were sampled at 7 and 60 days of ensiling. The results showed that the FA treatment contained highest NFC in both ensiled CF and SPV. Compared with the untreated silages, FA treatment inhibited the decrease of CP in the SPV silage while it did not affect CP content in the CF silage. The FA treatment prohibited the elevation of A+B_1 fraction during the first 7 days of ensiling and NH_3-N concentration during the later ensiling period (7-60 days) for SPV, whereas it did not change protein fractions of CF silage. The results suggest that the FA treatment was effective to prohibit proteolysis during ensiling SPV, while it was not effective to change protein fraction of the CF silage.

In chapter 4, nutrient utilization of sheep fed the ensiled forage of tuber crops were investigated (Experiment 4 and 5). The Experiment 4 aimed to clarify the effect of replacing alfalfa hay (AH) with a mixture of CF silage and SPV silage (CSP) (1:1 on a DM basis) on ruminal and intestinal nutrient digestion in sheep. Four wethers fitted with ruminal and duodenal cannula were fed following three diets: the control diet contained 35% of AH, while the treatment diets contained 15% or 30% of the CSP as substitute for AH. These diets were given at 1.5 times the metabolizable energy required for maintenance. Replacing AH with the CSP silage did not affect DM intake, whereas it linearly increased the intake of ether extract and acid detergent insoluble nitrogen (ADIN). Increasing the CSP substitution linearly decreased ruminal DM and NDF digestibility; however, it did not affect total tract NDF digestibility. The CSP substitution did not affect nitrogen (N) intake and duodenal total N flow, whereas it linearly increased duodenal ADIN flow and decreased ruminal NH_3-N concentration, and intestinal and total N digestibility. These results indicate that replacing AH with the CSP reduced the ruminal N degradation as well as the digestion of ruminal NDF and intestinal N.

The experiment 5 aimed to investigate the effects of ensiling tuber crop forages with formic acid (FA) addition and grain source on nutrient digestion, N utilization, and urea metabolism in sheep. The experimental diets consisted of either untreated or FA-treated (5 g/kg

fresh matter) CF silage and SPV silage combined with either corn or barley grain. Four wethers fitted with ruminal and duodenal cannula were assigned to a 4×4 Latin square design with a 2×2 factorial arrangement with silage treatment and grain source as the main effects. The diets contained 12% CP in DM (10.6 and 11.2 MJ metabolizable energy/kg DM for the barley- and corn-based diets, respectively) and comprised forage (60% DM; made up of 15% DM of CF silage, 15% DM of SPV silage, and 30% DM of oat hay) and concentrate (40% DM). The sheep were provided with dietary DM at 2.2% of body weight. Urea metabolism was determined by constant intravenous infusion of [$^{15}N_2$]urea and analyses of collected blood. Compared with their respective untreated silages, the FA-treated CF and SPV silages had higher NFC content and lower soluble protein content, respectively. The dietary treatments did not affect DM intake, but the total tract DM digestibility was lower for the barley-based diets than for the corn-based diets. The ruminal and total tract digestion of NFC were higher for the corn-based diets than for the barley-based diets, and higher for the FA-treated silage diets than for the untreated silage diets. NDF digestion in the rumen and total tract were higher for the barley-based diets than for the corn-based diets, but were not affected by the silage treatment. Ruminal pH and total VFA concentration did not differ among the diets, but the ruminal NH_3-N concentration was lower for the FA-treated silage diets than for the untreated silage diets. The intake and total digestion of N were higher for the corn-based diets than for the barley-based diets, but net ruminal N loss and ruminal microbial N synthesis were similar among the treatments. Urea-N production was the lowest for the barley-based FA-treated silage diet. In conclusion, the use of FA-treated tuber crop silages improved NFC digestion and reduced the ruminal NH_3-N concentration, but did not affect ruminal microbial N synthesis, or ruminal/intestinal N digestion in sheep. Combining barley grain with FA-treated silage reduced urea-N production in sheep.

In summary, the ensiling kudzu vine harvested in October was better to use as forage for ruminant due to the highest photosynthetic pigments and NFC content and lowest NDF content. Even though ensiling fresh kudzu vine reduced the NFC content and increased soluble protein fraction, ensiling with FA addition or wilting could increase the remained NFC content and decrease soluble protein fraction in the silage. In addition, FA treatment was effective to preserve NFC and reduce soluble protein elevation during ensiling SPV, while it did not change protein fraction during ensiling CF. The usage of CF silage and SPV silage as mixture could partly substitute with AH as alternative forage for ruminant owing to resembling NDF digestibility and N use in the rumen, even though it reduced N digestibility in sheep. The utilization of CF and

SPV ensiling with FA treatment improved NFC digestion and modify ruminal fermentation profile. The combination of these silages with corn grain enhanced NFC digestion, while the combination with barley grain decreased hepatic urea production in mature sheep. The correlation analysis indicates that the N use in ruminant fed the tuber-crop forage silages related to B_2 protein fraction, which had strong relationship with total chlorophyll content of these forages. Thus, B_2 protein fraction can be used as bio-marker to estimate protein quality of the local forages. The supply of high digestible NFC source with local forage silages would improve the efficiency of nutrient utilization in ruminants.