Effects of Different Combinations of Oat Hay and Whole-Plant Corn Silage on Rumen Fermentation in Sheep (Postprint)

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Abstract

This study was conducted to investigate the effects of different proportions of oat hay and whole-plant corn silage combinations on rumen fermentation in sheep. Nine crossbred (Merino × Mongolian) rams, weighing (70.24$±2.03)*kgwithsimilarbodyconditionandfittedwithpermanentrumenfistulas*, *wereselectedasexperimen* 3)*basedonbodyweightmeasuredduringthetransitionperiod.Threedietarytreatmentswereformulatedbasedont* *plantcornsilageintheforage*(*drymatterbasis*) : *A*1(100×$3 Latin square design was employed with three experimental periods, each lasting 22 days (15-day preliminary period and 7-day formal experimental period), and sampling was conducted on the last 3 days of the formal experimental period. The results showed: 1) Compared with 100% whole-plant corn silage, using 50% whole-plant corn silage + 50% oat hay or 100% oat hay as forage had no significant effect on mean rumen fluid pH and total nitrogen concentration in sheep (P>0.05), but significantly reduced mean concentrations of rumen fluid ammonia nitrogen (NH3-N), urea nitrogen, and serum urea nitrogen (P<0.05). Additionally, using 50% whole-plant corn silage + 50% oat hay as forage significantly increased mean rumen fluid protein nitrogen concentration (P<0.05). Moreover, mean rumen fluid pH and total nitrogen concentration in group A2 were slightly higher than those in group A3, mean rumen fluid protein nitrogen concentration increased by 8.97% compared with group A3, and mean rumen fluid and serum urea nitrogen concentrations were slightly lower than those in group A3, but these differences were not significant (P>0.05), while mean rumen fluid NH3-N concentration was significantly lower than that in group A3 (P<0.05). 2) Inclusion of oat hay in the forage did not significantly alter mean total volatile fatty acid concentration and propionate molar proportion in sheep rumen fluid, but increased mean acetate, butyrate molar proportions, and acetate-to-propionate ratio, with significant differences observed between groups A3 and A1 (P<0.05). It can be concluded that under conditions of

identical concentrate composition and a concentrate-to-forage ratio of 35:65, using a mixture of 50% whole-plant corn silage and 50% oat hay as forage can improve the rumen environment of sheep to be conducive to rumen microbial growth, enhance rumen microbial activity and its utilization efficiency of ammonia (NH3), facilitate microbial protein synthesis, and increase the molar proportion of ruminal acetate and the acetate-to-propionate ratio.

Full Text

Effects of Different Combinations of Oat Hay and Corn Silage on Ruminal Fermentation of Sheep

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Abstract

This experiment investigated the effects of different proportions of oat hay and corn silage on ruminal fermentation in sheep. Nine crossbred (Merino × Mongolian) rams with similar body condition, weighing (70.24 ± 2.03) kg and fitted with permanent rumen cannulas, were selected and divided into three groups of three sheep each based on transitional period weighing results. Diets were formulated with three roughage combinations (dry matter basis): A1 (100% corn silage), A2 (50% corn silage + 50% oat hay), and A3 (100% oat hay), with a concentrate-to-forage ratio of 35:65 for all diets. A 3 × 3 Latin square design was employed across three experimental periods, each lasting 22 days (15-day pre-trial period and 7-day formal trial period). Samples were collected during the final 3 days of each formal trial period.

The results showed: (1) Compared with 100% corn silage, diets containing 50% oat hay + 50% corn silage or 100% oat hay as roughage did not significantly affect mean ruminal pH or total nitrogen concentration ($P > 0.05$), but significantly reduced mean concentrations of ruminal ammonia nitrogen (NH_3-N), urea nitrogen, and serum urea nitrogen ($P < 0.05$). Additionally, the 50% corn

silage + 50% oat hay diet significantly increased mean ruminal protein nitrogen concentration ($P < 0.05$). The A2 group exhibited slightly higher mean ruminal pH and total nitrogen concentration, slightly lower ruminal and serum urea nitrogen concentrations, and an 8.97% higher mean ruminal protein nitrogen concentration compared with the A3 group, though these differences were not significant ($P > 0.05$). However, mean ruminal NH_3-N concentration in A2 was significantly lower than in A3 ($P < 0.05$). (2) Inclusion of oat hay in the roughage did not significantly alter mean total volatile fatty acid (TVFA) concentration or propionate molar proportion, but increased mean acetate and butyrate molar proportions and the acetate/propionate ratio ($P < 0.05$), with the A3 group showing significantly higher values than the A1 group. In conclusion, under conditions of identical concentrate supplementation and a 35:65 concentrate-to-forage ratio, a mixed roughage of 50% corn silage and 50% oat hay can improve the ruminal environment for microbial growth, enhance microbial activity and ammonia utilization, promote microbial protein synthesis, and increase ruminal acetate proportion and acetate/propionate ratio.

Keywords: oat hay; ruminal fermentation; pH; nitrogen metabolism; volatile fatty acid

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Introduction

Oat (*Avena sativa*) serves as an important forage source in high-altitude, cold regions of northern China, characterized by easy cultivation, high yield, and broad adaptability, and is used to produce high-quality hay as a primary roughage for dairy cows and racehorses. Oat hay contains low neutral detergent fiber and is rich in water-soluble carbohydrates ($ $15%), offering excellent palatability. With the rapid development of animal husbandry in China, oat hay has become one of the main roughage sources for ruminants. According to Chinese customs data, from January to November 2016, China' s total oat hay imports reached 198,600 tons, representing a 48.20% year-over-year increase and marking the fifth consecutive year of growth exceeding 25%. Therefore, investigating the effects of oat hay as a roughage on ruminant production performance, digestion, metabolism, and ruminal fermentation holds significant academic and economic value.

Broderick et al. reported that naturally dried oat hay exhibits high ruminal degradability of crude protein. George et al. fed beef cattle oat hay as a sole diet at 60%, 80%, 100%, and 120% of ad libitum intake, finding that nitrogen excretion and deposition decreased significantly as feeding level decreased. Long et al. reported that feeding yaks oat hay at 30%, 60%, and 90% of ad libitum intake resulted in decreased dry matter digestibility with increasing hay levels. Singh et al. fed crossbred beef cattle diets containing 95% to 60% oat hay and observed no significant changes in ruminal nutrient concentrations. Liang et al. demonstrated that appropriate oat hay supplementation in diets effectively

reduced serum urea nitrogen concentration in pigs. Zhang et al. fed Tibetan sheep oat hay at 90%, 70%, 50%, and 30% of ad libitum intake, finding that restriction level significantly affected total VFA concentration and butyrate molar proportion. Sang et al. reported that in vitro fermentation trials with dairy cows showed oat hay produced 40% higher total VFA concentration than corn silage, with significantly lower acetate and VFA molar proportions, indicating that oat hay' s high carbohydrate content and greater rumen utilization proportion favorably regulate ruminal fermentation. However, few studies have reported on the effects of oat hay as a roughage on ruminal fermentation in sheep. This study combined oat hay and corn silage at different proportions in sheep diets to investigate their effects on ruminal fermentation, identify optimal oat hay inclusion levels, and explore the relationship between oat hay and ruminal fermentation characteristics to provide a scientific basis for oat hay utilization in sheep production.

1. Materials and Methods

1.1 Experimental Animals and Diets Nine crossbred (Merino × Mongolian) rams fitted with permanent rumen cannulas were used as experimental animals. All sheep were healthy and disease-free, with an average body weight of (70.24 ± 2.03) kg and average rectal temperature of 39.6°C.

Three diets were formulated using corn, soybean meal, cottonseed meal, rapeseed meal, limestone, premix, and salt as concentrate, with different proportions of oat hay and corn silage as roughage, according to Chinese sheep feeding standards (NY/T 816-2004). Diet A1 contained 100% corn silage as roughage, A2 contained 50% corn silage + 50% oat hay, and A3 contained 100% oat hay. All diets had a concentrate-to-forage ratio of 35:65. Oat hay was purchased from Yongjie Grass and Livestock Co., Ltd. in Xiahe County, Gannan Prefecture, Gansu Province, while other diet components were sourced from Huajia Animal Husbandry in Lintao County, Dingxi City, Gansu Province. Diet samples were air-dried and ground using a micro plant grinder to pass through a 1 mm sieve for nutrient analysis. Oat hay was chopped into 2–3 cm lengths using a forage chopper, while whole-plant corn silage was used without processing. The nutritional composition comparison between oat hay and corn silage is presented in Table 1 , and diet composition and nutrient levels are shown in Table 2 .

1.2 Experimental Design and Management The experiment was conducted at Huajia Animal Husbandry Ranch in Lintao County, Dingxi City, Gansu Province, from November 2014 to March 2015. A 3 × 3 Latin square design was employed, with nine experimental sheep divided into three groups of three based on transitional period weighing results. Each group received the three experimental diets during different periods. Each period consisted of a 15-day pre-trial phase and a 7-day formal trial phase. Sheep were fed individually by mixing ground concentrate with chopped oat hay and corn silage accord-

ing to the prescribed concentrate-to-forage ratio to ensure consumption of the complete diet composition. Feed was provided twice daily (at 08:00 and 18:00), with 4 hours allowed for consumption, and sheep had free access to water. The experimental design is shown in Table 3 .

1.3 Sample Collection

1.3.1 Residual Feed Collection During the final 3 days of each formal trial period, feed offered was measured individually before morning and evening feeding. After ensuring adequate consumption, residual feed was collected in aluminum boxes and stored in the laboratory.

1.3.2 Rumen Fluid Collection On the final day of each formal trial period, rumen fluid (60 mL) was collected from each sheep via the rumen cannula at 07:30 (pre-feeding), 09:00 (1 h post-feeding), 11:00 (3 h post-feeding), 13:00 (5 h post-feeding), and 15:00 (7 h post-feeding). Samples were placed in an insulated container, and pH was measured and recorded immediately. Fluid was filtered through four layers of cheesecloth, collected in sampling tubes, mixed with 1.5 mL of pre-prepared saturated mercuric chloride ($HgCl_2$) solution for enzyme deactivation, and immediately stored at -20°C.

1.3.3 Blood Collection Concurrent with rumen fluid collection, approximately 10 mL of blood was collected from the jugular vein using vacuum tubes containing the anticoagulant dipotassium ethylenediaminetetraacetate. Blood was centrifuged at 3,500 r/min for 10 min to separate serum, which was placed in a foam box with ice packs and immediately transported to the laboratory for serum urea nitrogen determination.

1.4 Laboratory Analyses

1.4.1 Dry Matter Intake Determination Residual feed was oven-dried at 65°C for 20 h to determine dry matter content, and dry matter intake was calculated based on residual feed dry matter.

1.4.2 Rumen Fluid pH Determination Rumen fluid pH was measured using an HI98103 high-precision pen-type pH meter (Beijing Taiyasaifu Company).

1.4.3 Rumen Fluid Total Nitrogen Concentration Determination Total nitrogen concentration in rumen fluid was determined using the semi-micro Kjeldahl method.

1.4.4 Rumen Fluid Ammonia Nitrogen (NH_3-N) Concentration Determination NH_3-N concentration was determined using the modified colorimetric method of Feng Zongci. The standard curve equation was Y = 0.578X ($R^2 = 0.998$), where X represents NH_3-N mass (mg) and Y represents absorbance. Rumen fluid sample volume for analysis was 0.4 mL.

1.4.5 Rumen Fluid and Serum Urea Nitrogen Concentration Determination Rumen fluid and serum urea nitrogen concentrations were determined using the diacetyl-monoxime method (reagent kits purchased from Nanjing Jiancheng Bioengineering Institute).

1.4.6 Rumen Fluid Protein Nitrogen Concentration Calculation Protein nitrogen concentration (mg/dL) = Total nitrogen concentration (mg/dL) - Urea nitrogen concentration (mg/dL) -NH_3-N concentration (mg/dL).

1.4.7 Rumen Fluid Volatile Fatty Acid (VFA) Composition Determination Total VFA concentration and molar proportions of acetate (AA), propionate (PA), and butyrate (BA) were determined using an Agilent 1260 high-performance liquid chromatograph. Chromatographic conditions: SB-AQ C18 column (4.6 mm × 250 mm); mobile phase A (methanol): mobile phase B (0.01 mol/L diammonium hydrogen phosphate, pH = 2.70) = 3:97; flow rate 1 mL/min; injection volume 20 µL; detection wavelength 210 nm; column temperature 25°C.

1.5 Data Processing and Analysis All data were pre-processed using Excel 2013 and analyzed using SPSS 17.0 software for one-way ANOVA, with multiple comparisons performed using Tukey' s method. Significance was declared at $P < 0.05$.

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2. Results and Analysis

2.1 Changes in Dry Matter Intake of Sheep Under Different Oat Hay and Corn Silage Combinations As shown in Table 4 , the proportion of oat hay to corn silage in the diet did not significantly affect dry matter intake ($P > 0.05$). However, mean dry matter intake values indicated a trend toward increased intake with the 50% corn silage + 50% oat hay combination.

2.2 Changes in Rumen Fluid pH of Sheep Under Different Oat Hay and Corn Silage Combinations As shown in Table 5 , rumen fluid pH decreased significantly after feeding compared with pre-feeding values, reaching its lowest point at 3 h post-feeding, then gradually increasing thereafter. No significant differences in pre-feeding pH were observed among groups. At 1 and 3 h post-feeding, pH was highest in group A2, significantly higher than in group A1 ($P < 0.05$). At 5 h post-feeding, pH was highest in group A3, significantly

higher than in group A1 ($P < 0.05$). No significant differences were found among groups at other time points or in mean pH values ($P > 0.05$). Although pre-feeding pH in group A2 was slightly lower than in group A1, pH values at all post-feeding time points were higher, resulting in the highest average value.

2.3 Changes in Rumen Fluid Total Nitrogen Concentration of Sheep Under Different Oat Hay and Corn Silage Combinations As shown in Table 6 , total nitrogen concentration increased rapidly after feeding, then fluctuated over time: group A1 peaked at 3 h post-feeding, declined sharply to its lowest at 5 h, then gradually recovered; group A2 peaked at 1 h post-feeding, declined gradually to its lowest at 5 h, then recovered; group A3 also peaked at 1 h post-feeding but reached its lowest at 3 h before gradually recovering. Total nitrogen concentration in groups A1 and A3 essentially returned to pre-feeding levels by 7 h post-feeding, while group A2 remained 19.29% higher than pre-feeding levels and was significantly higher than group A1 ($P < 0.05$). Additionally, group A2 had the highest mean total nitrogen concentration at 144.61 mg/dL, 9.49% and 6.66% higher than groups A1 and A3, respectively, though these differences were not significant ($P > 0.05$).

2.4 Changes in Rumen Fluid NH_3-N Concentration of Sheep Under Different Oat Hay and Corn Silage Combinations As shown in Table 7 , rumen fluid NH_3-N concentration increased rapidly after feeding, peaking at 1 h post-feeding in all groups, then declining to its lowest at 5 h before recovering. Mean NH_3-N concentration was significantly reduced by oat hay inclusion ($P < 0.05$), with group A2 (50% oat hay + 50% corn silage) showing the lowest value at 11.54 mg/dL, 37.44% and 11.96% lower than groups A1 and A3, respectively ($P < 0.05$).

2.5 Changes in Rumen Fluid Urea Nitrogen Concentration of Sheep Under Different Oat Hay and Corn Silage Combinations As shown in Table 8 , rumen fluid urea nitrogen concentration patterns were similar across groups, decreasing after feeding to 最低点 at 3 or 5 h, then gradually recovering. Mean urea nitrogen concentration was significantly lower in groups A2 and A3 (containing oat hay) compared with group A1 ($P < 0.05$).

2.6 Changes in Rumen Fluid Protein Nitrogen Concentration of Sheep Under Different Oat Hay and Corn Silage Combinations As shown in Table 9 , protein nitrogen concentration dynamics varied among groups: group A1 showed no change at 1 h post-feeding, peaked at 3 h, then declined; group A2 increased rapidly to peak at 1 h, declined to its lowest at 5 h, then increased sharply; group A3 showed relatively stable overall changes. Mean protein nitrogen concentration was significantly increased by oat hay inclusion ($P < 0.05$), with group A2 showing the highest value at 131.06 mg/dL, 16.58% higher than group A1 ($P < 0.05$) and 9.03% higher than group A3 ($P > 0.05$).

2.7 Changes in Serum Urea Nitrogen Concentration of Sheep Under Different Oat Hay and Corn Silage Combinations As shown in Table 10 , serum urea nitrogen concentration patterns were consistent across groups, increasing after feeding to peak at 3 h, then gradually declining. Mean serum urea nitrogen concentration was significantly lower in groups A2 and A3 (containing oat hay) compared with group A1 ($P < 0.05$).

2.8 Changes in Rumen Fluid VFA Composition of Sheep Under Different Oat Hay and Corn Silage Combinations As shown in Table 11 , no significant differences were observed among groups in TVFA concentration or propionate molar proportion at any time point or in mean values ($P > 0.05$). Mean acetate and butyrate molar proportions were significantly higher in group A3 than in group A1 ($P < 0.05$). The acetate/propionate ratio decreased sharply at 1 h post-feeding, then gradually recovered to pre-feeding levels by 7 h. Mean acetate/propionate ratio was highest in group A3, significantly higher than in groups A1 and A2 ($P < 0.05$).

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3. Discussion

3.1 Effects of Different Oat Hay and Corn Silage Combinations on Dry Matter Intake and Rumen Fluid pH in Sheep Different proportions of oat hay and corn silage in sheep diets did not significantly affect dry matter intake, though mean values across three periods showed a trend toward increased intake with oat hay inclusion. Rumen fluid pH is a crucial indicator of ruminal fermentation level, providing direct assessment of relative stability in the ruminal environment. Rumen pH results from interactions among diet type, rumen buffers, saliva, digestion and excretion of acidic and alkaline substances, and water. Under normal conditions, rumen pH ranges from 5.00 to 7.50. In this experiment, rumen pH ranged from 5.74 to 6.67, with a mean around 6.20, following the pattern of decreasing after feeding then increasing, reaching its lowest point at 3–5 h post-feeding. This likely occurred because dietary carbohydrates were degraded by rumen microorganisms upon entering the rumen, producing VFAs that decreased pH, which then gradually increased as carbohydrates were digested and VFAs absorbed by the rumen wall, diluted by saliva buffer. Han et al. reported that feeding dairy goats diets with different non-fibrous carbohydrate (NFC)/neutral detergent fiber (NDF) ratios resulted in decreased rumen pH after feeding, reaching its lowest at 3–6 h before recovering, with pH ranging from 5.30 to 6.84. Wang et al. reported that feeding beef cattle different roughage types resulted in decreased rumen pH after feeding, reaching its lowest at 2–4 h before recovering to pre-feeding levels. Similar results were obtained in this study, with no significant differences in mean pH among groups, indicating that changing roughage type at 30–50% concentrate levels does not substantially affect rumen pH.

Mound et al. reported that rumen fibrolytic bacteria are only active when pH

is above 6.00. Ørskov et al. also noted that higher rumen pH favors fibrolytic bacterial proliferation and microbial protein synthesis. Zhou et al. found that replacing corn silage with oat hay increased populations of three fibrolytic bacteria species in mixed diets compared with corn silage alone, favoring rumen environment stability and regulation. In this study, mean rumen pH was higher in sheep fed the 50% corn silage + 50% oat hay diet compared with those fed 100% oat hay or 100% corn silage, suggesting that this combination is more conducive to microbial growth and rumen environment stability.

3.2 Effects of Different Oat Hay and Corn Silage Combinations on Rumen Nitrogen Metabolism in Sheep Dietary protein must undergo complex ruminal nitrogen metabolism and be degraded by rumen microorganisms before ultimately synthesizing microbial protein that can be absorbed by the animal. Therefore, ruminal nitrogen metabolism level is closely related to ruminal fermentation degree. The primary nitrogen source in the rumen is dietary protein degradation, mainly including urea nitrogen, NH_3-N, and protein nitrogen. The main factors affecting ruminal total nitrogen concentration are the total amount of protein ingested and its ruminal degradability. In this study, total nitrogen concentration increased rapidly after feeding due to dietary protein degradation, then decreased as microorganisms utilized nitrogenous substances for growth, and increased again as microbial protein synthesis continued. Although protein intake was similar across the three diets, naturally dried oat hay typically has high ruminal protein degradability, and feeding oat hay increased rumen pH, which is more favorable for microbial growth and microbial protein synthesis. Consequently, mean total nitrogen concentration was significantly higher in group A2 than in group A1. Rumen NH_3-N is a primary substrate for microbial protein synthesis, and its concentration is mainly affected by dietary protein degradation characteristics and microbial protein synthesis rate. Microbial growth and protein synthesis require an appropriate NH_3-N concentration, with the optimal range being 6.30–27.50 mg/dL. In this study, ruminal NH_3-N concentration ranged from 7.08 to 16.53 mg/dL, within the optimal range for microbial growth and protein synthesis. The rapidly degradable portion of dietary protein increased NH_3-N concentration, which then gradually decreased as protein degradation slowed and rumen microorganisms utilized ammonia for protein synthesis, reaching its lowest at 5 h post-feeding. As microbial protein synthesis rate slowed, ammonia accumulated in the rumen, causing NH_3-N concentration to gradually increase again, approaching pre-feeding levels by 7 h post-feeding in group A1. Rumen urea nitrogen primarily originates from dietary urea nitrogen, and both the ability of rumen microorganisms to utilize urea nitrogen for microbial protein synthesis and animal feeding speed affect its concentration. Dietary urea nitrogen is extensively used by rumen microorganisms under urease action to synthesize microbial protein, while decreased microbial activity reduces urea nitrogen utilization, explaining the pattern of decreased then increased ruminal urea nitrogen concentration after feeding. Mean values showed that oat hay inclusion reduced ruminal NH_3-N and urea nitro-

gen concentrations while significantly increasing protein nitrogen concentration, likely because diets containing oat hay created a rumen environment more conducive to microbial growth, and highly degradable oat hay provided abundant available energy for rumen microbial proliferation, promoting microbial growth and increasing urease activity, thereby enhancing ammonia and urea nitrogen utilization for microbial protein synthesis. Ariza et al. also found that including roughage rich in water-soluble carbohydrates (WSC) in diets could improve microbial protein synthesis efficiency and reduce ruminal NH_3-N concentration.

3.3 Effects of Different Oat Hay and Corn Silage Combinations on Serum Urea Nitrogen Concentration in Sheep Serum urea nitrogen concentration is an important indicator of protein metabolism and accurately reflects dietary amino acid balance. Rumen NH_3-N not utilized for microbial protein synthesis is partially absorbed through the rumen epithelium into blood as serum urea nitrogen. Darlis et al. reported that serum urea nitrogen concentration is positively correlated with ruminal NH_3-N concentration. This study' s results are consistent with Darlis et al., as serum urea nitrogen concentration in all three groups increased then decreased over time post-feeding, following a similar pattern to ruminal NH_3-N concentration. Oat hay inclusion reduced serum urea nitrogen concentration because oat hay, compared with corn silage, better maintained rumen homeostasis, promoted microbial growth and reproduction, and increased microbial utilization of ammonia for microbial protein synthesis, thereby decreasing ruminal NH_3-N concentration and consequently reducing serum urea nitrogen concentration.

3.4 Effects of Different Oat Hay and Corn Silage Combinations on Rumen VFA Composition in Sheep Dietary carbohydrates must be fermented by rumen microorganisms to produce VFAs before absorption by the animal. As primary energy sources, VFA production, individual VFA molar proportions, and fermentation type depend mainly on diet composition. In this study, ruminal propionate molar proportion increased at 1 h post-feeding, then decreased slowly, approaching pre-feeding levels by 7 h. Acetate and butyrate molar proportions decreased at 1 h post-feeding, then gradually increased. Based on the proportion of each VFA in TVFA, the changing trends of acetate, propionate, butyrate, and TVFA concentrations in rumen fluid were consistent—increasing after feeding then decreasing. Large amounts of VFAs were produced through rumen fermentation after feeding, then gradually decreased as energy was utilized for microbial protein synthesis and VFAs were absorbed by the rumen wall. Mean values showed that oat hay inclusion did not significantly affect ruminal TVFA concentration or propionate molar proportion but significantly increased acetate and butyrate molar proportions and the acetate/propionate ratio, with group A3 showing significantly higher values than group A1. Rumen VFAs in ruminants consist primarily of acetate, propionate, and butyrate, accounting for approximately 95% of TVFA. Increased acetate proportion favors higher body fat and milk fat percentages, increased propionate proportion

favors glucose conversion and storage, and butyrate provides energy for various tissues. In this study, group A3 had higher mean acetate and butyrate proportions and lower propionate proportion than group A1, likely because cellulose and hemicellulose fermentation produces higher acetate proportions, while sugar and starch fermentation produces higher propionate proportions. Different roughage types result in varying populations of fibrolytic bacteria and fibrolytic enzyme activities, producing different acetate and propionate proportions. Since oat hay is rich in crude fiber and WSC while corn silage has higher starch content, group A3 exhibited significantly higher acetate proportion and acetate/propionate ratio than group A1 under identical concentrate levels, along with lower propionate proportion.

Conclusion

1. Under conditions of identical concentrate supplementation and a 35:65 concentrate-to-forage ratio, oat hay inclusion in roughage did not significantly affect dry matter intake but improved ruminal ammonia utilization and protein nitrogen concentration, with slightly higher rumen pH.
2. Oat hay inclusion in roughage increased ruminal acetate and butyrate molar proportions and elevated the acetate/propionate ratio in sheep.
3. Among the three oat hay and corn silage combinations, the 50% corn silage + 50% oat hay combination demonstrated the best overall effects.

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Note: Figure translations are in progress. See original paper for figures.