

## Effects of dietary non-fibrous carbohydrate to neutral detergent fiber ratio on growth performance, apparent nutrient digestibility, and methane production in growing Duhan cross-bred ewes under different feeding systems: A postprint

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### Abstract

This experiment was conducted to investigate the effects of dietary non-fibrous carbohydrate (NFC) to neutral detergent fiber (NDF) ratio on growth performance, apparent nutrient digestibility, and methane production in growing Dorper × Han crossbred ewes using an open-circuit respiratory calorimetry system. A single-factor experimental design was adopted, and 30 ewes with good body condition and body weight of (27.8±0.5) kg were selected and allocated to 3 groups according to the principle of consistent body weight. The dietary NFC/NDF ratios for each group were 0.78 (concentrate-to-forage ratio of 35:65), 1.03 (concentrate-to-forage ratio of 50:50), and 2.17 (concentrate-to-forage ratio of 65:35), with 10 ewes per group. The experimental period lasted 25 d, including a 3 d adaptation period, a 7 d preliminary period, and a 15 d formal experimental period. The results showed that: under the conditions of ad libitum feeding in the NFC/NDF=0.78 group and restricted feeding in the other groups, there were no significant differences in initial body weight, final body weight, and average daily gain among the three groups ( $P>0.05$ ). When dietary NFC/NDF ratio increased from 0.78 to 2.17, dry matter intake decreased significantly ( $P<0.05$ ), while apparent digestibility of dry matter, organic matter, and crude protein increased significantly ( $P<0.05$ ), with no significant differences in apparent digestibility of NDF and acid detergent fiber (ADF) ( $P>0.05$ ). When dietary NFC/NDF ratio increased from 0.78 to 2.17, methane energy, methane yield per unit dry matter intake, and methane energy output per unit gross energy intake decreased significantly ( $P<0.05$ ). The results suggest that, un-

der the premise of consistent average daily gain, high NFC/NDF diets have lower feed-to-gain ratios and lower methane conversion efficiency; for growing Dorper × Han crossbred ewes, feeding a diet with NFC/NDF ratio of 2.17 under restricted feeding conditions achieves relatively the best effect in improving production efficiency while considering methane emission reduction.

## Full Text

### Effects of Dietary Non-fiber Carbohydrate (NFC)/Neutral Detergent Fiber (NDF) on Growth Performance, Nutrient Apparent Digestibility and Methane Emissions of Growing Dorper and Thin-Tailed Han Crossbred Ewes

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**Abstract:** This study investigated the effects of dietary non-fiber carbohydrate (NFC)/neutral detergent fiber (NDF) on growth performance, nutrient apparent digestibility and methane emissions of growing Dorper and thin-tailed Han crossbred ewes using an open-circuit respiratory system. Thirty healthy ewes with body weight of (27.8±0.5) kg were allocated to three groups according to a single-factor experimental design, with dietary NFC/NDF ratios of 0.78 (concentrate:forage = 35:65), 1.03 (concentrate:forage = 50:50) and 2.17 (concentrate:forage = 65:35), respectively, and 10 ewes per group. The experiment lasted for 25 days, including a 3-day adjustment period, a 7-day preliminary period and a 15-day formal trial period. The results showed that under ad libitum feeding conditions for the NFC/NDF=0.78 group and restricted feeding for the other groups, there were no significant differences in initial body weight, final body weight or average daily gain among the three groups (P>0.05). As dietary NFC/NDF increased from 0.78 to 2.17, dry matter intake (DMI) decreased significantly (P<0.05), while apparent digestibility of dry matter, organic matter and crude protein increased significantly (P<0.05). No significant differences were observed in apparent digestibility of NDF and acid detergent fiber (ADF) among groups (P>0.05). With increasing dietary NFC/NDF from 0.78 to 2.17, methane energy, methane emission per unit DMI, and methane energy per unit gross energy intake decreased significantly (P<0.05). These results indicate that under similar average daily gain, high NFC/NDF diets result in lower feed to gain ratios and lower methane conversion efficiency. For growing Dorper

and thin-tailed Han crossbred ewes, feeding a diet with NFC/NDF of 2.17 under restricted feeding conditions is relatively optimal for improving production efficiency while simultaneously reducing methane emissions.

**Keywords:** methane; non-fiber carbohydrate/neutral detergent fiber; growth performance; digestibility and metabolism; respirometry

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### 1.1 Time and Location

The experiment was conducted at the NanKou Pilot Base Sheep Farm of the Chinese Academy of Agricultural Sciences from December 2016 to May 2017.

### 1.2 Experimental Design

A single-factor experimental design was employed using Dorper ( ) × small-tailed Han ( ) crossbred F1 ewes as experimental animals. Thirty healthy ewes with body weight of (27.8±\$0.52) kg were selected and allocated to three groups based on the principle of consistent body weight. The dietary NFC/NDF ratios were 0.78 (concentrate:forage = 35:65), 1.03 (concentrate:forage = 50:50) and 2.17 (concentrate:forage = 65:35), with 10 ewes per group. Total mixed pellet diets were formulated according to NRC (2007) standards, with premix provided by Beijing Precision Animal Nutrition Research Center. The composition and nutrient levels of experimental diets are shown in . Throughout the experimental period, the NFC/NDF=0.78 group was fed ad libitum, while the other two groups were restrictively fed, with free access to water. The experiment lasted 25 days, comprising a 3-day adjustment period, a 7-day preliminary period and a 15-day formal trial period.

### 1.3 Animal Management

Experimental ewes were housed individually, with each ewe occupying approximately 2.6 m<sup>2</sup>. During the trial, the maximum temperature was 21.2°C, minimum temperature was 18.9°C, and average temperature was 17.1°C. Prior to the preliminary period, each ewe was administered 2.5 mL of ivermectin solution for deworming. The ad libitum feed intake of the NFC/NDF=0.78 group was adjusted daily based on the previous day' s intake to ensure approximately 10% refusals in the feed trough. Feed was offered twice daily at 08:00 and 17:00, with free access to water. Feed samples were collected before feeding, and refusals from the previous day were weighed accurately and sampled after thorough mixing. Both feed intake and refusal amounts were strictly recorded to calculate dry matter intake (DMI) for each group throughout the experimental period.

### 1.4 Digestion and Metabolism Trial

During the formal trial period, feces and urine were collected daily before morning feeding using the total collection method. For fecal collection, the collection

bags were removed from each ewe and weighed to record the previous day's fecal output. Fecal samples were then thoroughly mixed, and 10% of the total weight was sampled. For urine collection, 100 mL of 10% H<sub>2</sub>SO<sub>4</sub> was added to each urine collection bucket prior to collection to preserve urinary nitrogen. After collection, the urine volume for each ewe was recorded, filtered through four layers of gauze, and 10% of the total volume was sampled.

### 1.5 Gas Metabolism Trial

Methane emissions were measured using an open-circuit gas metabolism system (Sable, USA), which connected three respiratory chambers allowing simultaneous measurement of three ewes. Each chamber was equipped with a feed trough and water trough, enabling ewes to feed and drink freely during the measurement period. On days 1, 4, 7, 10 and 13 of the formal trial period, experimental animals were placed in the chambers in five batches (3 ewes per batch, one from each group). After 24 hours of adaptation, methane production, carbon dioxide production (GGA, Los Gatos Research, USA) and oxygen consumption (FC-10 oxygen analyzer, Sable, USA) were measured for 48 hours. The measurement system completed four cycles every 30 minutes. At the start of each measurement, ambient methane concentration was measured for 2 minutes, followed by 1 minute of air replacement from environment to chamber, then methane production from each of the three chambers was measured sequentially for 2 minutes per chamber, followed by 1 minute of air replacement from chambers to environment, and finally ambient methane concentration was measured again for 2 minutes. This completed one measurement cycle, which was repeated continuously for 48 hours. The average of the two ambient methane measurements was used as the baseline value, and methane production per ewe per day was calculated using the macro file corresponding to the open-circuit gas metabolism system's measurement program. Body weight was measured when ewes entered and exited the gas metabolism chambers, and the average of the two measurements was used to calculate metabolic body weight.

#### 1.6.1 Growth Performance

Before morning feeding each day, refusals from the NFC/NDF=0.78 group were recorded, and the next day's intake was adjusted based on the refusal proportion to ensure ad libitum feeding levels. The other two groups had their feed intake adjusted every 5 days based on weighing results to ensure similar average daily gain to the ad libitum group. Both feed intake and refusal amounts were strictly recorded to calculate DMI for each ewe throughout the trial period. Body weight changes were recorded to calculate average daily gain (ADG) and feed to gain ratio (F/G).

#### 1.6.2 Sample Analysis and Determination

After the digestion and gas metabolism trials, fecal, dietary and refusal samples from each ewe were dried in a 65°C oven for 48 hours, equilibrated for 24 hours

and weighed to determine initial moisture content. Samples were then ground through a 40-mesh sieve to prepare analytical samples for determination of dry matter (DM), crude ash, crude protein (CP), ether extract (EE), neutral detergent fiber (NDF) and acid detergent fiber (ADF) content, as well as gross energy (GE), fecal energy (FE), urinary energy (UE), calcium (Ca) and phosphorus (P) content according to “Feed Analysis and Feed Quality Detection Technology” [4].

## 1.7 Statistical Analysis

Experimental data were initially processed using Excel 2007. Statistical analysis was performed using SAS 9.4 software with ANOVA for testing data independence, normality and homogeneity of variance. Duncan’s multiple comparison test was used when differences were significant, with  $P < 0.05$  as the criterion for significant difference.

## 2.1 Growth Performance

shows the effects of dietary NFC/NDF on growth performance of growing Dorper and thin-tailed Han crossbred ewes. No significant differences were observed in initial body weight, final body weight or ADG among the three groups ( $P > 0.05$ ). The ADG for NFC/NDF=0.78, NFC/NDF=1.03 and NFC/NDF=2.17 groups were 169.93, 162.47 and 157.10 g/d, respectively, with no significant differences among groups ( $P > 0.05$ ). DMI in the NFC/NDF=2.17 group (1,290.00 g/d) was significantly lower than in the NFC/NDF=0.78 group (1,790.00 g/d,  $P < 0.05$ ), but not significantly different from the NFC/NDF=1.03 group (1,412.00 g/d,  $P > 0.05$ ). Additionally, the feed to gain ratio in the NFC/NDF=2.17 group (8.43) was significantly lower than in the NFC/NDF=0.78 group (10.57,  $P < 0.05$ ), while the NFC/NDF=1.03 group showed no significant differences from the other two groups ( $P > 0.05$ ).

## 2.2 Nutrient Apparent Digestibility

presents the effects of dietary NFC/NDF on nutrient apparent digestibility of growing Dorper and thin-tailed Han crossbred ewes. As dietary NFC/NDF increased, apparent digestibility of dry matter and organic matter increased, with the NFC/NDF=2.17 group being significantly higher than both the NFC/NDF=0.78 and NFC/NDF=1.03 groups ( $P < 0.05$ ), while no significant difference was observed between the latter two groups ( $P > 0.05$ ). Crude protein apparent digestibility increased with increasing dietary NFC/NDF, with the NFC/NDF=0.78 group being significantly lower than both the NFC/NDF=2.17 and NFC/NDF=1.03 groups, which did not differ significantly from each other ( $P > 0.05$ ). NDF apparent digestibility increased with increasing dietary NFC/NDF, but no significant differences were detected among the three groups ( $P > 0.05$ ). ADF apparent digestibility decreased with increasing dietary NFC/NDF, with no significant differences among groups ( $P > 0.05$ ).

### 2.3 Energy Metabolism

illustrates the effects of dietary NFC/NDF on energy metabolism of growing Dorper and thin-tailed Han crossbred ewes. Gross energy intake (GEI) decreased with increasing dietary NFC/NDF, with no significant difference between the NFC/NDF=1.03 and NFC/NDF=2.17 groups (25.58 vs. 22.91 MJ/d,  $P>0.05$ ), but both were significantly lower than the NFC/NDF=0.78 group ( $P<0.05$ ). Digestible energy intake showed the same trend, while no significant differences were observed in metabolizable energy intake among the three groups ( $P>0.05$ ). Fecal energy and methane energy in the NFC/NDF=0.78 group were significantly higher than in the other two groups ( $P<0.05$ ), at 15.62 and 3.14 MJ/d, respectively, while urinary energy showed no significant differences ( $P>0.05$ ). Both gross energy apparent digestibility and gross energy metabolic rate increased significantly with increasing dietary NFC/NDF ( $P<0.05$ ).

### 2.4 Methane Emissions

demonstrates the effects of dietary NFC/NDF on methane emissions of growing Dorper and thin-tailed Han crossbred ewes. Daily methane emission in the NFC/NDF=0.78 group was 79.32 L/d, significantly higher than in the NFC/NDF=1.03 group (60.58 L/d) and NFC/NDF=2.17 group (36.07 L/d) ( $P<0.05$ ). Similarly, methane emission per unit metabolic body weight increased significantly with increasing dietary NFC/NDF ( $P<0.05$ ), with values of 5.79, 4.36 and 2.57 L/(kg BW<sup>0.75</sup> · d) for the NFC/NDF=0.78, NFC/NDF=1.03 and NFC/NDF=2.17 groups, respectively. Methane emission per unit DMI, per unit organic matter intake, per unit digestible organic matter intake and per unit digestible NDF intake all decreased with increasing dietary NFC/NDF, with no significant differences between the NFC/NDF=0.78 and NFC/NDF=1.03 groups ( $P>0.05$ ), but both were significantly higher than the NFC/NDF=2.17 group ( $P<0.05$ ). Methane energy per unit GEI in the NFC/NDF=0.78 and NFC/NDF=1.03 groups were 10.25 and 9.35, respectively, significantly higher than the 6.32 in the NFC/NDF=2.17 group ( $P<0.05$ ), though no significant difference existed between the former two groups ( $P>0.05$ ). Methane energy per unit digestible energy intake and per unit metabolizable energy intake showed the same trend. No significant differences were observed in methane emission per unit ADG among the three groups ( $P>0.05$ ).

## Discussion

Ruminants utilize their unique rumen system to degrade recalcitrant fibrous materials through microbial action to produce energy for the body. Previous studies have shown that different physiological stages, feeding modes and dietary nutritional composition can affect nutrient and energy digestion and metabolism efficiency, as well as rumen fermentation performance and methane production. This experiment investigated the effects of three dietary NFC/NDF ratios under both ad libitum and restricted feeding conditions on growth performance,

nutrient apparent digestibility and methane emissions in Dorper and thin-tailed Han crossbred ewes.

### 3.1 Effects of Dietary NFC/NDF on Growth Performance of Dorper and Thin-Tailed Han Crossbred Ewes

Feeding mode and dietary nutritional composition can affect growth indicators such as feed intake, weight gain and feed to gain ratio in ruminants. Zhang et al. [5] used a single-factor completely randomized design to investigate the effects of different dietary NDF proportions at the same crude protein level on growth performance of Dorper and thin-tailed Han crossbred sheep. The results showed that although net weight gain and ADG were not significantly different, DMI was positively correlated with dietary NDF proportion ( $R^2=0.74$ ). In this experiment, dietary NFC/NDF had no significant effect on initial body weight, final body weight or ADG, but DMI decreased significantly as dietary NFC/NDF increased from 0.78 to 2.17. Unlike the maintenance level set by Ding et al. [6], ewes under restricted feeding conditions (NFC/NDF=1.03 and NFC/NDF=2.17 groups) in this study achieved similar ADG and final body weight to the ad libitum group (NFC/NDF=0.78) with lower DMI and organic matter intake. Additionally, the feed to gain ratio under restricted feeding conditions, especially in the NFC/NDF=2.17 group, was significantly lower than in the ad libitum NFC/NDF=0.78 group, indicating that high-concentrate diets under restricted feeding can meet maintenance requirements while allowing excess nutrients to be directly used for production, thus saving costs. The experimental diets were formulated as total mixed pellets according to NRC (2007) standards for sheep with a target ADG of 250 g/d, but the actual ADG was lower than the target, possibly due to the applicability of NRC (2007) standards to Dorper and thin-tailed Han crossbred sheep in Chinese production systems and the influence of seasonal temperature during the experiment.

### 3.2 Effects of Dietary NFC/NDF on Nutrient Apparent Digestibility and Energy Metabolism

Previous studies have shown that dietary structure is the main factor determining nutrient digestibility. Lignin binds hemicellulose through covalent bonds and encapsulates cellulose molecules, making them difficult to be utilized by rumen microorganisms. Wang et al. [7] investigated the effects of different concentrate:forage ratios in total mixed pellet diets on nutrient apparent digestibility, nitrogen metabolism and energy metabolism in ewes. The results showed that as dietary NDF proportion increased (from 33.96% to 53.29%), apparent digestibility of nutrients (dry matter, organic matter and crude protein) decreased significantly, NDF apparent digestibility first increased then decreased, total tract nitrogen digestibility increased significantly, and dietary digestible energy, metabolizable energy and gross energy apparent digestibility showed an overall increasing trend. Although this experiment set different feeding modes (ad libitum and restricted) than Wang et al. [7], the increase in dietary NFC/NDF led to

more rapidly degradable and utilizable substances in the diet, which favored the proliferation of fiber-degrading and protein-degrading bacteria, thereby significantly increasing apparent digestibility of nutrients (dry matter, organic matter and crude protein), consistent with the findings of Liu et al. [8]. Tyrrell and Moe [9] proposed that gross energy intake is positively correlated with fecal energy excretion, consistent with the results of Xu et al. [10] and Wang et al. [7]. In this experiment, gross energy intake, fecal energy, urinary energy, methane energy, digestible energy intake and metabolizable energy intake all decreased with increasing dietary NFC/NDF. It is speculated that when dietary NFC proportion increases, rumen fermentation pattern shifts from acetate-type to propionate-type fermentation. The increased propionate and butyrate content during fermentation of fermentable organic matter can stimulate rumen papillae development, increasing papillae number, length and width per unit area, thereby enhancing rumen epithelial absorption of volatile fatty acids [11] and improving dietary nutrient digestibility. Additionally, increased DMI in this experiment inevitably increased NDF intake per unit, allowing more nutrients to be transferred to the intestine for degradation, thus increasing total tract NDF digestibility [12]. Although the decrease in rumen NDF digestibility was smaller than the decrease in rumen starch digestibility, the greater impact on crude fiber digestibility may explain the observed decrease in ADF apparent digestibility with increasing NFC/NDF.

### 3.3.1 Effects of Feed Intake on Methane Emissions

Numerous studies have shown that DMI is positively correlated with methane production in ruminants. High feeding levels increase rumen digesta passage rate, reducing fermentation time, contact area and passage rate between substrates and rumen microorganisms, altering rumen microbial populations and volatile fatty acid fermentation patterns, which can explain 28% of methane emissions [13-16]. Benchaar et al. [17] used corn-soybean meal diets to study the effects of four DMI levels (9, 12, 15 and 17 kg/d) on rumen fermentation and methane production. The results showed that methane energy production increased with DMI (6.86, 8.83, 10.67 and 11.76 MJ/d), while methane energy per unit gross energy intake tended to decrease (5.33, 5.17, 4.98 and 4.85). This experiment set both ad libitum and restricted feeding modes, with ewe DMI decreasing from 1,790.00 g/d to 1,290.00 g/d as dietary NFC/NDF increased. Methane production decreased from 79.32 L/d to 36.07 L/d, and methane emission per unit DMI decreased from 46.85 L/kg to 30.23 L/kg. Guo et al. [18] used sulfur hexafluoride ( $\text{SF}_6$ ) tracer technique to measure methane production in Inner Mongolia white cashmere goats under maintenance and ad libitum feeding conditions, finding that methane production (17.71 and 18.06 g/d) was positively correlated with DMI (0.581 and 0.839 kg/d). Zhao et al. [19] set three different feed intake levels (ad libitum, 75% ad libitum and 55% ad libitum) for crossbred sheep and found a significant positive correlation between methane production and DMI: methane production (L/d) =  $44.03 \times \text{DMI (kg/d)} - 6.52$  ( $R^2=0.68$ ), consistent with the conclusions of Feng et al. [20] in dairy and beef

cattle. Benchaar et al. [17] measured rumen liquid and solid phase passage rates at different DMI levels through simulation, finding that passage rates increased by 37.5% and 39.6%, respectively, with increasing DMI, verifying the positive correlation between rumen digesta passage rate and DMI [21]. High DMI groups increased substrate supply for methane production [22-23], allowing sufficient fermentation of fibrous materials in the rumen and shifting rumen fermentation pattern toward acetate-type fermentation, which favors growth and proliferation of fiber-degrading and methanogenic bacteria, resulting in higher methane production.

### **3.3.2 Effects of Nutrient Apparent Digestibility and Energy Utilization Efficiency on Methane Emissions**

Methane emission per unit DMI [22] and methane energy per unit gross energy intake [Intergovernmental Panel on Climate Change (IPCC), 2006] are the main indicators for assessing methane conversion efficiency and methane production. Methane energy per unit gross energy intake is primarily affected by feeding level [24]. Mould et al. [25] proposed that high-concentrate diets increase rumen acidity and starch effects, negatively affecting the activity of rumen fiber-degrading bacteria. Sang et al. [26] studied the effects of different concentrate:forage ratios on methane production in Xinjiang fine-wool sheep fed low-quality and high-quality roughage, finding that methane production efficiency from low-quality roughage decreased significantly with increasing concentrate ratio, while high-quality roughage with higher digestible fiber content was not significantly affected by concentrate ratio. In this experiment, methane emission per unit DMI and methane energy per unit gross energy intake in the NFC/NDF=2.17 group were significantly lower than in the NFC/NDF=0.78 group, indicating that high NFC/NDF favors propionate-type fermentation, promotes uptake of soluble carbohydrates and soluble protein by rumen microorganisms, increases clearance of hydrogen produced during rumen pyruvate metabolism, and inhibits growth and proliferation of fiber-degrading and methanogenic bacteria. Since fiber components produce 2-5 times more methane than non-fiber components, methane production in the sheep gastrointestinal tract was substantially reduced. Additionally, compared with the NFC/NDF=0.78 group, the NFC/NDF=1.03 group decreased fecal energy, urinary energy and methane energy while increasing gross energy apparent digestibility and metabolic rate, indicating that carbohydrate fermentation rate and content affect energy utilization in microbial growth [27]. Higher dietary fermentability can increase microbial biomass production and enhance energy utilization efficiency, thereby reducing energy loss in the form of methane energy and consequently decreasing gastrointestinal methane production.

### **3.3.3 Effects of Dietary NFC/NDF on Methane Emissions**

The concentrate:forage ratio in ruminant diets can affect volatile fatty acid production and acetate:propionate ratio in the rumen, altering substrate avail-

ability during pyruvate metabolism and ultimately affecting methane production. Previous studies have found that concentrate:forage ratio alone cannot accurately represent fermentable carbohydrates and fiber in diets and cannot serve as a decisive factor for evaluating methane production [28]. NFC mainly refers to nitrogen-free extract in diets, including starch, sugars, pectin, vitamins and organic acids that are readily fermentable, and can more objectively reflect the content of easily fermentable carbohydrates in diets. Roughage contains high fiber content; ruminants cannot utilize lignin but can better utilize cellulose and hemicellulose in crude fiber, and NDF can better reflect fiber content and fiber digestion characteristics. Therefore, NFC/NDF can more truly reflect the proportion of carbohydrates and fiber in diets. Ding et al. [6] found that daily methane production decreased gradually with decreasing dietary NFC/NDF, consistent with the conclusions of Chandramoni et al. [29] and Moss et al. [30]. The main reasons may be: 1) Increased dietary NFC proportion shifts rumen fermentation pattern from acetate-type to propionate-type fermentation, decreasing acetate:propionate ratio and reducing hydrogen concentration (the substrate for methanogens), thereby decreasing methane production; 2) Methanogenic bacteria and protozoa have a symbiotic relationship in the rumen, with protozoa providing hydrogen for methanogens. Increased dietary NFC proportion alters the growth and structure of dominant rumen microbial populations, inhibiting protozoal growth and consequently reducing methane production [31-32]. Liu et al. [8] conducted experiments in sheep fitted with rumen and duodenal cannulas and found that as dietary non-structural carbohydrate (NSC)/structural carbohydrate (SC) ratio increased, propionate content in total volatile fatty acids increased slightly (non-significantly) while acetate content decreased significantly, indicating that propionate-type fermentation became dominant with increasing NSC/SC, inhibiting growth and proliferation of fiber-degrading and methanogenic bacteria and decreasing methane production. Hu et al. [28] studied the effects of different dietary NFC/NDF ratios on rumen pH, volatile fatty acids and lactic acid content in dairy goats fitted with permanent rumen cannulas, finding that rumen fermentation pattern changed with increasing NFC/NDF, with acetate content gradually decreasing and propionate content gradually increasing, and inferred that dietary NFC proportion could alter rumen fermentation type, consistent with the findings of Weng [33]. In this experiment, methane production was 46.85 L per kg of diet intake in the NFC/NDF=0.78 group, compared with 43.36 L/d and 30.23 L/d in the NFC/NDF=1.03 and NFC/NDF=2.17 groups, respectively, mainly due to differences in DMI and NFC/NDF among the three groups, which affected rumen fermentation pattern and methanogenic capacity.

## Conclusions

1. Under the premise of similar average daily gain, both feeding level and dietary NFC/NDF are factors affecting methane production. High NFC/NDF diets result in lower feed to gain ratios and lower methane conversion efficiency.

2. For growing Dorper and thin-tailed Han crossbred ewes, feeding a diet with NFC/NDF of 2.17 under restricted feeding conditions is relatively optimal for improving production efficiency while simultaneously reducing methane emissions.

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