Effects of Dietary Non-fibrous Carbohydrate to Neutral Detergent Fiber Ratio on Growth Performance, Slaughter Performance, and Organ Indices of Cashmere Goat Kids (Postprint)

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Abstract

This experiment aimed to investigate the effects of feeding different non-fibrous carbohydrate (NFC)/neutral detergent fiber (NDF) ratios in all-roughage and total mixed diets on growth performance, slaughter performance, and organ indices of Albas white cashmere goat kids under confined feeding conditions. A single-factor completely randomized experimental design was adopted, in which 40 4-month-old weaned wether kids were divided into a control group (CG group) and an experimental group (EG group), with 4 replicates per group and 5 kids per replicate. The CG group was fed an all-roughage diet with NFC/NDF ratios of 0.13, 0.12, and 0.12 in the early, middle, and late fattening stages, respectively, while the EG group was fed a total mixed diet with a concentrate-to-forage ratio of 50:50, with NFC/NDF ratios of 0.78, 0.77, and 0.77. At the end of the experiment, 8 kids were selected from each of the CG and EG groups for slaughter. The preliminary feeding period was 14 d, and the formal experimental period was 90 d. The results showed: 1) Compared with the CG group, the final body weight and total weight gain of kids in the EG group increased significantly ($P<0.05$), dry matter intake tended to decrease ($P>0.05$), and feed conversion ratio decreased significantly ($P<0.05$). 2) Compared with the CG group, carcass weight, dressing percentage, loin eye area, and GR value of kids in the EG group increased significantly ($P<0.05$); the weights of heart, liver, lungs, kidneys, head, hide, and blood increased significantly ($P<0.05$). 3) The proportion of abomasum weight to total compound stomach weight in kids of the EG group was significantly lower than that of the CG group ($P<0.05$); the proportions of rumen weight and abomasum weight to pre-slaughter live weight were significantly lower than those of the CG group ($P<0.05$). The proportion of large intestine weight to pre-slaughter live weight and small intestine weight

in kids of the EG group were significantly lower than those of the CG group (P<0.05). The results indicated that, compared with feeding a total mixed diet with NFC/NDF of 0.77–0.78, feeding an all-roughage diet with NFC/NDF of 0.12–0.13 reduced the growth performance, slaughter performance, and development rate of visceral organs in Albas white cashmere goat kids, but increased the proportion of gastrointestinal weight to body weight.

Full Text

Effects of Dietary NFC/NDF on Growth Performance, Slaughter Performance, and Organ Indexes of Cashmere Goat Kids

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Abstract

This study investigated the effects of diets with different non-fibrous carbohydrate (NFC) to neutral detergent fiber (NDF) ratios on growth performance, slaughter performance, and organ indexes of Albas white cashmere goat kids under stall-feeding conditions. A single-factor completely randomized design was employed, allocating 40 weaned castrated male kids at 4 months of age into a control group (CG) and an experimental group (EG), each comprising 4 replicates of 5 goats. The CG received a roughage-only diet with NFC/NDF ratios of 0.13, 0.12, and 0.12 during the early, middle, and late fattening periods, respectively. The EG received a total mixed ration with a concentrate-to-forage ratio of 50:50, with NFC/NDF ratios of 0.78, 0.77, and 0.77 across the three periods. At the conclusion of the trial, 8 goats from each group were selected for slaughter. The preliminary period lasted 14 days, followed by a 90-day formal experimental period. Results demonstrated: (1) Compared with the CG, the EG exhibited significantly increased final body weight and total weight gain (P<0.05), a tendency toward reduced dry matter intake (P=0.057), and significantly decreased feed-to-gain ratio (P<0.05). (2) The EG showed significantly greater carcass weight, dressing percentage, loin eye area, and GR value (P<0.05), along with significantly increased weights of heart, liver, lung, kidney, head, skin, and blood (P<0.05). (3) The proportion of abomasum weight to total complex stomach weight was significantly lower in the EG (P<0.05), as were the proportions of rumen and abomasum weights to pre-slaughter live weight (P<0.05). Additionally, the proportion of large intestine weight to pre-slaughter live weight and the absolute small intestine weight were significantly lower in the EG (P<0.05). These findings indicate that compared with a total mixed ration with NFC/NDF of 0.77–0.78, a roughage-only diet with NFC/NDF of

0.12–0.13 reduced growth performance, slaughter performance, and visceral organ development rate in Albas white cashmere goat kids, while increasing the proportion of gastrointestinal tract weight relative to body weight.

Keywords: cashmere goats; growth performance; slaughter performance; organ indexes

Introduction

Albas white cashmere goats are a world-renowned dual-purpose breed valued for both cashmere and meat production. Their cashmere is celebrated globally for its fineness, length, softness, and texture, while their meat is prized for its flavor and lack of mutton odor, offering substantial market potential. However, declining cashmere prices, rising demand for goat meat, deteriorating grassland ecosystems, and restrictions on grazing capacity have collectively made stall-feeding of cashmere goat kids an emerging economic opportunity. In practice, stall-feeding typically requires increasing dietary concentrate proportions to improve fattening efficiency. Nevertheless, high concentrate-to-forage ratios result in elevated NFC and reduced NDF content, which can decrease rumen pH and induce acidosis. Despite improving fattening efficiency, such diets may negatively affect rumen fermentation and animal health, potentially compromising meat quality.

Dietary concentrate-to-forage ratio represents a primary factor influencing meat quality differences. Research by Wang Ziyuan on Dazu black goats demonstrated that increasing dietary concentrate ratio progressively decreased the unsaturated to saturated fatty acid ratio in meat, reducing beneficial fatty acid content. Roughage-only stall-feeding offers an alternative that alleviates pressure on natural grasslands and circumvents grazing capacity limitations while potentially improving meat quality despite lower fattening efficiency. Liméa et al. found that feeding Caribbean goats a low NFC/NDF roughage diet, though reducing growth and slaughter performance, significantly increased intramuscular n-3 polyunsaturated fatty acid deposition, aligning better with healthy food standards. However, the specific effects of low NFC/NDF roughage diets compared with high NFC/NDF total mixed rations on growth performance, slaughter performance, and organ indexes in cashmere goat kids remain unclear. Therefore, this study compared the effects of different NFC/NDF diets on these parameters in Albas white cashmere goat kids under stall-feeding conditions, providing data to support rational fattening program development and improved production efficiency.

1.1 Experimental Animals and Design

This experiment employed a single-factor completely randomized design. Forty healthy weaned castrated male Albas white cashmere goat kids at 4 months of age, with similar body weights, were selected from a breeding farm culling

group and randomly divided into a control group (CG) and an experimental group (EG). Each group contained 4 replicates with 5 goats per replicate. The preliminary period lasted 14 days, followed by a 90-day formal trial comprising three phases: early (days 1–30), middle (days 31–60), and late (days 61–90). The CG received a roughage-only diet composed of alfalfa hay, oat hay, and corn stalks, with NFC/NDF ratios of 0.13, 0.12, and 0.12 across the three phases (concentrate-to-forage ratio 0:100). The EG received a total mixed ration with a concentrate-to-forage ratio of 50:50, with NFC/NDF ratios of 0.78, 0.77, and 0.77, respectively. All goats were stall-fed throughout the trial, receiving feed twice daily (08:00 and 15:00) with free access to water. The total mixed ration was formulated according to Chinese Feeding Standards for Meat Goats (2004), while the roughage diet was formulated based on the nutritional levels of natural pasture forages consumed by Albas white cashmere goats. Dietary composition and nutrient levels are presented in Table 1 .

1.2.1 Growth Performance

Initial body weight was recorded for each goat at the trial' s commencement, with subsequent weighings conducted every two weeks at 07:00 after overnight fasting. Total weight gain was calculated at the trial' s conclusion. Daily feed allocation and refusals were recorded by replicate to calculate dry matter intake (DMI) and feed-to-gain ratio (total feed intake kg / total weight gain kg).

1.2.2 Slaughter Performance

At the trial' s conclusion, 8 goats from each group were selected for slaughter after 12 hours of feed withdrawal and 2 hours of water withdrawal. Pre-slaughter live weight, carcass weight, dressing percentage, loin eye area, and backfat thickness (GR value) were determined. Dressing percentage was calculated as the ratio of carcass weight to pre-slaughter live weight. Carcass weight was measured 30 minutes post-slaughter after blood removal, dehairing, head removal, evisceration, and removal of distal limb portions below the carpal and tarsal joints. Loin eye area was measured on the left carcass between the 12th and 13th ribs using the formula: loin eye area (cm^2) = loin eye height × width × 0.7. The GR value represented tissue thickness at a point 11 cm from the dorsal midline between the 12th and 13th ribs.

1.2.3 Organ Indexes

Following slaughter, viscera and intestines were rapidly separated to weigh the heart, liver, spleen, lungs, kidneys, small intestine, and large intestine, with each organ' s proportion to pre-slaughter live weight calculated. The rumen, reticulum, omasum, and abomasum were separated and weighed to determine each compartment' s proportion to total complex stomach weight and to pre-slaughter live weight.

1.3 Data Processing

Data were analyzed using SAS 9.0 software with t-tests. Differences were considered significant at $P<0.05$ and non-significant at $P>0.05$.

2.1 Effects of Different NFC/NDF Diets on Growth and Slaughter Performance

As shown in Table 2 , compared with the CG, the EG exhibited significantly increased final body weight and total weight gain ($P<0.05$), a tendency toward decreased DMI ($P=0.057$), and significantly reduced feed-to-gain ratio ($P<0.05$).

Table 2 demonstrates that the EG achieved superior growth performance with lower feed conversion ratios. Table 3 further reveals that the EG showed significantly increased pre-slaughter live weight, carcass weight, dressing percentage, loin eye area, and GR value compared with the CG ($P<0.05$).

2.2 Effects of Different NFC/NDF Diets on Organ Indexes and Tissue Development

Table 4 indicates that the EG exhibited significantly increased weights of heart, liver, lung, and kidney ($P<0.05$), along with a significantly elevated proportion of liver weight to pre-slaughter live weight ($P<0.05$). Table 5 shows that the EG demonstrated significantly greater weights of head, skin, and blood compared with the CG ($P<0.05$).

Table 6 reveals that rumen weight was numerically higher in the EG, while omasum and abomasum weights were numerically lower, though these differences were not statistically significant ($P>0.05$). Reticulum weight tended to be higher in the EG ($P=0.057$). The proportion of abomasum weight to total complex stomach weight was significantly lower in the EG ($P<0.05$), as were the proportions of rumen and abomasum weights to pre-slaughter live weight ($P<0.05$). The proportion of omasum weight to pre-slaughter live weight tended to decrease in the EG ($P=0.062$). Table 7 shows that small intestine weight and the proportion of large intestine weight to pre-slaughter live weight were significantly lower in the EG ($P<0.05$).

3.1 Effects of Different NFC/NDF Diets on Growth and Slaughter Performance

In recent years, increasing demand for goat meat, deteriorating grassland ecosystems, and grazing capacity limitations have made stall-feeding the primary method for cashmere goat kid production. Production practice typically requires increasing dietary concentrate proportions to enhance fattening efficiency, though high-concentrate feeding with elevated NFC/NDF may reduce meat quality and flavor. Wang Ziyuan investigated dietary concentrate-to-forage ratios

(40:60, 30:70, 20:80, 10:90) in stall-fed Dazu black goats and found that increasing NFC/NDF progressively decreased the unsaturated to saturated fatty acid ratio, reducing fatty acid profiles consistent with modern healthy food standards. Liméa et al. studied Caribbean goats fed roughage-only diets versus supplemented concentrates, finding that low NFC/NDF roughage increased n-3 polyunsaturated fatty acid content beneficial for consumer health. Thus, roughage-only stall-feeding can alleviate natural grassland pressure, avoid grazing capacity limitations, and prevent meat quality reduction associated with high-concentrate feeding. However, low NFC/NDF reduces nutritional levels, hindering animal development and decreasing fattening efficiency and slaughter performance. Albas white cashmere goats, developed under the specific dry, cold, windy conditions of the Ordos Plateau, have been traditionally managed through natural grazing. Previous research has focused primarily on reproductive performance and cashmere quality, with limited reports on the effects of different NFC/NDF diets on fattening performance and organ indexes under stall-feeding conditions.

Diet represents the primary factor affecting ruminant growth and slaughter performance. Xu Xiangting et al. reported that increasing dietary concentrate proportion in weaned Dorper ram lambs increased average daily gain while significantly decreasing average daily intake and feed-to-gain ratio, with similar results reported by Wen Qi et al. Feed-to-gain ratio serves as a crucial economic indicator for fattening lambs, while carcass weight and dressing percentage are important slaughter performance metrics that directly reflect growth performance. Loin eye area indicates carcass development degree and typically correlates positively with carcass weight, while greater pre-slaughter live weight yields greater carcass weight. The present study yielded similar results, with total mixed ration feeding promoting growth rate and feed conversion efficiency while improving slaughter performance. Compared with the total mixed ration group (NFC/NDF = 0.77–0.78), the roughage-only group (NFC/NDF = 0.12–0.13) showed reductions of 15.85%, 34.81%, 19.61%, 34.81%, and 76.09% in total weight gain, carcass weight, dressing percentage, loin eye area, and GR value, respectively. Backfat thickness (GR value) serves as a marker for carcass fat content, increasing with dietary energy levels. In this trial, the roughage-only group exhibited lower energy and protein levels but higher NDF and ADF content, resulting in reduced NFC/NDF and consequently lower GR values. Additionally, as animals develop, consumed nutrients are increasingly directed toward fat deposition, enabling higher dressing percentages, which partially explains the reduced GR values and dressing percentage in the roughage-only group.

3.2 Effects of Different NFC/NDF Diets on Organ Indexes and Tissue Development

Organ and tissue weights and their indexes reflect animal development and functional status, holding significance for both theoretical research and production practice. Animals can regulate visceral organ development to match overall

growth. Johnson et al. demonstrated that visceral tissue mass relates to energy utilization, with organ development accelerating as dietary energy intake increases. As a vital metabolic organ, the liver must grow rapidly to maintain normal metabolism. The present results indicate that the higher NFC/NDF total mixed ration promoted development of heart, liver, lung, kidney, and spleen, with significantly increased liver weight proportion to pre-slaughter live weight, suggesting that higher NFC/NDF synchronized visceral organ development with overall growth. Conversely, the low NFC/NDF roughage diet, with its high fiber content, reduced dietary passage rate through the gastrointestinal tract, decreasing digestibility of organic matter, NFC, crude protein, and fat, thereby impairing organ development.

Ruminant complex stomach development directly affects feed intake and digestive capacity. Johnson et al. reported that fermentable fiber is the primary dietary component promoting intestinal development, with digestive tract weight related to absorbable nutrient quantity. Feeding roughage alone can stimulate rumen muscular layer development and promote rumination and salivary flow. High dietary crude fiber content increases intestinal weight and muscular layer thickness, expanding intestinal mucosal area and affecting papillae morphology, ultimately influencing intestinal development. Similar results were observed in this trial, with the roughage-only group showing higher proportions of rumen, omasum, abomasum, and intestinal weights to pre-slaughter live weight compared with the total mixed ration group. Song Xiaowen et al. reported that high-energy diets promoted development of non-carcass tissues including feet, skin, and wool in Laoshan dairy goats. The present study found significantly greater head, skin, and blood weights in the total mixed ration group, consistent with these reports. Thus, the significantly elevated gastrointestinal proportion in the roughage-only group contributed to reduced dressing percentage and carcass weight.

Overall, although the roughage-only group exhibited significantly reduced growth and slaughter performance with increased gastrointestinal weight proportion, the decreased visceral proportion and GR values suggest that low NFC/NDF roughage diets may reduce fat deposition while increasing lean meat proportion, benefiting consumer health demands. Previous research indicates that roughage-only feeding can decrease intramuscular fat content while increasing n-3 polyunsaturated fatty acids, with pasture-fed lambs showing superior fatty acid profiles compared with concentrate-supplemented counterparts. However, under the stall-feeding conditions of this trial, the specific changes in fatty acid composition and meat quality between low and high NFC/NDF groups require further investigation. Additionally, the roughage-only diet was formulated based on natural pasture nutritional levels without premix supplementation, which may have limited growth and slaughter performance. Future research should optimize roughage diet nutritional levels to further investigate fattening efficiency and slaughter performance patterns, providing a theoretical foundation for improved cashmere goat kid fattening programs.

4 Conclusion

Compared with a total mixed ration containing NFC/NDF of 0.77–0.78, a roughage-only diet with NFC/NDF of 0.12–0.13 reduced growth performance, slaughter performance, and visceral organ development rate in Albas white cashmere goat kids, while increasing the proportion of gastrointestinal tract weight to body weight.

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