Effects of Replacing Alfalfa with Ramie at Different Ratios on Growth Performance, Serum Biochemical Parameters, and Nutrient Apparent Digestibility in Boer Goats (Postprint)

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Abstract

This study aimed to investigate the effects of replacing different proportions of alfalfa with ramie on growth performance, serum biochemical indices, and nutrient apparent digestibility in Boer goats. Seventy-five Boer goat kids aged approximately 3 months with similar body weight [(17.51±1.79) kg] were selected and randomly allocated to 5 groups using a single-factor experimental design, with 5 replicates per group and 3 goats per replicate. The control group was fed a basal diet, while the four experimental groups were fed experimental diets in which alfalfa in the basal diet was equivalently replaced with ramie at 25% (Experimental Group I), 50% (Experimental Group II), 75% (Experimental Group III), and 100% (Experimental Group IV). The experiment consisted of a 15-day preliminary period followed by a 75-day formal experimental period. On day 60 of the formal experimental period, a 4-day digestion and metabolism trial was initiated for the experimental kids, during which feces were collected, and blood samples were taken on the final day of the experiment. The results showed: 1) The contents of crude protein, crude fat, calcium, neutral detergent fiber, acid detergent fiber, and crude ash in ramie were all higher than those in alfalfa. 2) Compared with the control group, the average daily gain of goats in Experimental Groups I, II, and III decreased by 1.93%, 6.16%, and 20.74%, respectively, with no significant differences ($P>0.05$); the average daily gain of goats in Experimental Group IV decreased by 27.38% and 25.96% compared with the control group and Experimental Group I, respectively, with significant differences ($P<0.05$). 3) Compared with the control group, no significant changes ($P>0.05$) were observed in serum total protein, albumin, globulin, albumin/globulin ratio, creatinine, and free thyroxine contents in goats after replacing alfalfa with different proportions of ramie; the serum free triiodothyronine content in each

experimental group decreased to varying degrees compared with the control group, with the differences reaching significant levels (P<0.05) in Experimental Groups II, III, and IV; uric acid was detected in the serum of goats in Experimental Group IV, but not in the control group or other experimental groups. 4) No significant differences (P>0.05) were observed in the apparent digestibility of dry matter, crude protein, crude fat, neutral detergent fiber, acid detergent fiber, and total phosphorus in goats among all experimental groups compared with the control group; however, the apparent digestibility of calcium in Experimental Group IV decreased by 11.69% (P<0.05), 11.57% (P<0.05), 11.71% (P<0.05), and 7.79% (P>0.05) compared with the control group, Experimental Group I, Experimental Group II, and Experimental Group III, respectively. In conclusion, ramie has relatively high nutritional value and can be efficiently utilized as a high-quality forage to partially replace alfalfa in the diet of Boer goats.

Full Text

Effects of Ramie Substituting Different Ratios of Alfalfa on Growth Performance, Serum Biochemical Indexes and Nutrient Apparent Digestibility of Boer Goats

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Abstract

This study investigated the effects of ramie substituting different ratios of alfalfa on growth performance, serum biochemical indexes, and nutrient apparent digestibility in Boer goats. Seventy-five healthy Boer goat kids approximately 3 months old, with similar initial body weight of (17.51±1.79) kg, were randomly assigned to five groups using a single-factor experimental design. Each group comprised five replicates with three goats per replicate. The control group received a basal diet, while four experimental groups received diets in which 25% (trial group I), 50% (trial group II), 75% (trial group III), and 100% (trial group IV) of alfalfa in the basal diet were replaced with equivalent amounts of ramie. The pretrial period lasted 15 days, followed by a 75-day formal trial period. A 4-day digestion-metabolism trial was initiated on day 60 of the formal trial to collect fecal samples, and blood samples were collected on the final day of the experiment.

The results showed: 1) Ramie contained higher levels of crude protein, ether extract, calcium, neutral detergent fiber (NDF), acid detergent fiber (ADF), and

crude ash compared to alfalfa. 2) Compared with the control group, the average daily gain (ADG) of trial groups I, II, and III decreased by 1.93%, 6.16%, and 20.74%, respectively, with no significant differences (P>0.05). The ADG of trial group IV decreased by 27.38% and 25.96% compared to the control group and trial group I, respectively, showing significant differences (P<0.05). 3) Serum total protein, albumin, globulin, albumin/globulin ratio, creatinine, and free thyroxine showed no significant changes across all groups (P>0.05). However, serum free triiodothyronine content decreased to varying degrees in all experimental groups, with significant differences observed in trial groups II, III, and IV compared to the control group (P<0.05). Uric acid was detected in the serum of goats in trial group IV, but not in the control group or other experimental groups. 4) No significant differences were observed among all groups in apparent digestibility of dry matter, crude protein, ether extract, NDF, ADF, or total phosphorus (P>0.05). However, calcium apparent digestibility in trial group IV decreased by 11.69% (P<0.05), 11.57% (P<0.05), 11.71% (P<0.05), and 7.79% (P>0.05) compared to the control group, trial groups I, II, and III, respectively. In conclusion, ramie possesses relatively high nutritional value and can be efficiently utilized as a high-quality forage to partially replace alfalfa in Boer goat diets.

Keywords: ramie; alfalfa; Boer goats; growth performance; serum biochemical indexes; nutrient apparent digestibility

Introduction

Ramie (*Boehmeria nivea*) is a perennial herbaceous plant in the Urticaceae family, characterized by rapid growth, strong branching ability, large leaves, high biomass yield, and favorable nutritional value. Recent studies have demonstrated that ramie leaves exhibit nutritional profiles similar to alfalfa, with high crude protein content, abundant amino acids, and moderate levels of neutral detergent fiber (NDF) and acid detergent fiber (ADF). The average crude protein, lysine, and threonine contents across seven annual harvests reached 19.57%, 0.84%, and 0.82%, respectively, with high rumen effective degradation rates and potential degradability for various nutrients. Research by Ridla et al. indicated that feeding goats with ramie leaves or silage improved dietary crude fat digestibility without significantly affecting crude protein, dry matter, organic matter, or crude fiber digestibility. Tang et al. investigated the effects of ramie meal on growth performance, slaughter performance, and meat chemical composition in meat rabbits, finding that dietary ramie meal inclusion up to 10% did not significantly impact daily gain, daily feed intake, or feed conversion ratio. These findings suggest that ramie can serve as a high-quality roughage in herbivorous livestock diets. However, ramie contains substantial amounts of anti-nutritional factors such as tannins and exhibits a severely imbalanced calcium-to-phosphorus ratio, which may limit its inclusion rate in animal diets.

Alfalfa is the most widely cultivated perennial legume forage globally, renowned as the "king of forages" due to its strong adaptability, high biomass yield, ex-

cellent nutritional quality, and palatability. Alfalfa is rich in protein, minerals, vitamins, and biologically active flavonoids, and contains highly digestible fiber that ferments in the rumen to produce volatile fatty acids as the primary energy source for ruminants. Consequently, alfalfa represents a premium forage source for cattle, sheep, and other ruminants. However, in southern China, high temperatures, humidity, and acidic soil conditions are extremely unfavorable for alfalfa growth, resulting in relatively underdeveloped alfalfa production in this region.

The shortage of high-quality forage in southern China has become a bottleneck constraining the healthy and rapid development of the grassland livestock industry. Developing and utilizing new, high-quality forage resources can help alleviate this shortage. Ramie grows normally in southern regions with high biomass yield and nutritional value. This experiment aimed to investigate the effects of substituting different proportions of alfalfa with ramie in total mixed rations on growth performance, blood biochemical indexes, and nutrient apparent digestibility in Boer goats, providing a theoretical basis for the efficient utilization of forage ramie as a high-quality roughage in herbivorous livestock diets and promoting the healthy development of the grassland livestock industry in southern China.

Materials and Methods

Ramie Harvesting and Preparation

The ramie variety used was "Emu Zhu 0904," a forage cultivar jointly developed by the Institute of Animal Husbandry and Veterinary Science of Hubei Academy of Agricultural Sciences and Xianning Academy of Agricultural Sciences, and cultivated at the Ramie Demonstration Base of Xianning Academy of Agricultural Sciences. The fourth cutting of ramie in 2016 was harvested in August (plant height 100–120 cm, harvested from the top down to 100 cm). After harvesting, the whole ramie plants were chopped to approximately 2 cm using a shredding machine and sun-dried for storage.

Alfalfa

The alfalfa used was Spanish imported alfalfa hay pellets provided by Shenzhen Guangda Technology Development Co., Ltd.

Experimental Animals and Design

Seventy-five Boer goat wethers approximately 3 months old, with similar initial body weight of (17.51±1.79) kg, were randomly assigned to five groups using a single-factor experimental design. Each group comprised five replicates with three goats per replicate. The control group received a basal diet, while four experimental groups received diets in which 25% (trial group I), 50% (trial group II), 75% (trial group III), and 100% (trial group IV) of alfalfa in the basal diet

were replaced with equivalent amounts of ramie. Diet composition and nutrient levels are presented in Table 1 . Diets were proportionally formulated, mixed, and pelleted using a self-designed pellet feed production line for feeding. The experiment was conducted at Hubei Tianyue Animal Husbandry Co., Ltd. in Duodao District, Jingmen City, Hubei Province, from October to December 2016, with a 15-day pretrial period and a 75-day formal trial period.

Feeding Management

During the experimental period, feeding troughs, water troughs, goat houses, pens, and passageways were disinfected according to routine farm procedures, and disease prevention and deworming were carried out following the company' s health protocols. Experimental goats were weighed consecutively for two days at the beginning and end of the pretrial period for grouping. During the formal trial period, goats in each group were fed according to the experimental design. Feeding occurred daily at 08:00 and 15:00 with ad libitum access to feed and water.

Growth Performance Measurement

At the end of the formal trial period, goats were weighed after fasting. Average feed consumption was recorded for each replicate to calculate average daily feed intake, average daily gain, and feed conversion ratio.

Serum Biochemical Indexes

At the end of the experiment, six goats were randomly selected from each group for blood collection from the jugular vein after weighing. Serum was separated and stored at -20°C for analysis. Serum biochemical indexes were determined by Wuhan Lanwei Medical Laboratory Co., Ltd.

Nutrient Apparent Digestibility

A 4-day digestion-metabolism trial was initiated on day 60 of the formal trial period. Daily feces were collected and weighed, with 30% of the collected feces placed in glass dishes and oven-dried at 65°C to constant weight. The 4-day fecal samples were then mixed, ground, and subsampled using the quartering method, and stored at -20°C for analysis. Daily feed intake was accurately recorded, and 200 g of diet samples were collected daily from each group. The 4-day diet samples were mixed, ground, and subsampled using the quartering method, and stored at -20°C for analysis. The collected fecal and diet samples were used to determine dry matter, crude protein, ether extract, calcium, total phosphorus, NDF, and ADF contents. Crude protein content was determined using the Kjeldahl method (Kjeltec 2300 Kjeldahl Analyzer, FOSS, Denmark). Dry matter, calcium, and total phosphorus contents were determined according to Zhang. NDF and ADF contents were determined using the method of Van Soest et al. Nutrient apparent digestibility was calculated using the formula:

Apparent digestibility of a nutrient (%) = 100 × [amount of nutrient ingested by test goat (g) - amount of nutrient excreted in feces (g)] / amount of nutrient ingested by test goat (g).

Statistical Analysis

Data were preliminarily processed using Excel 2007. One-way ANOVA was performed using SPSS 11.0, followed by Duncan' s multiple comparison tests. Results are expressed as mean ± standard error.

Results

Nutrient Composition of Ramie and Alfalfa

As shown in Table 2 , ramie exhibited higher crude protein, ether extract, and calcium contents compared to alfalfa, but also contained higher levels of NDF, ADF, and crude ash.

Effects of Ramie Substituting Different Ratios of Alfalfa on Growth Performance of Boer Goats

Table 3 presents the effects on growth performance. Compared with the control group, average daily gain (ADG) decreased to varying degrees after substituting different proportions of alfalfa with ramie. The ADG of trial groups I, II, and III decreased by 1.93%, 6.16%, and 20.74%, respectively, with no significant differences ($P>0.05$). The ADG of trial group IV decreased by 27.38% and 25.96% compared to the control group and trial group I, respectively, showing significant differences ($P<0.05$). Average daily feed intake of trial groups III and IV decreased by 8.04% and 14.67% compared to the control group, respectively, with significant differences ($P<0.05$). Feed conversion ratio in all trial groups increased significantly compared to the control group ($P<0.05$), and feed conversion ratio in trial groups III and IV was also significantly higher than in trial groups I and II ($P<0.05$).

Effects of Ramie Substituting Different Ratios of Alfalfa on Serum Biochemical Indexes of Boer Goats

Table 4 shows the effects on serum biochemical indexes. Compared with the control group, no significant differences were observed in serum total protein, albumin, globulin, albumin/globulin ratio, creatinine, or free thyroxine after substituting different proportions of alfalfa with ramie ($P>0.05$). Serum free triiodothyronine content decreased to varying degrees in all trial groups, with significant differences observed in trial groups II, III, and IV compared to the control group ($P<0.05$). Uric acid was detected in the serum of goats in trial group IV, but not in the control group or other trial groups.

Effects of Ramie Substituting Different Ratios of Alfalfa on Nutrient Apparent Digestibility of Boer Goats

As shown in Table 5 , no significant differences were observed among all groups in apparent digestibility of dry matter, crude protein, ether extract, NDF, ADF, or total phosphorus (P>0.05). However, calcium apparent digestibility in trial group IV decreased by 11.69% (P<0.05), 11.57% (P<0.05), 11.71% (P<0.05), and 7.79% (P>0.05) compared to the control group, trial groups I, II, and III, respectively.

Discussion

Alfalfa is a perennial legume forage with tender, soft stems and luxuriant leaves, rich in nutritional value and highly palatable. It can improve rumen fermentation in meat sheep, enhance nitrogen utilization and certain amino acid contents in the duodenum, and increase production performance as well as digestibility of crude protein, NDF, and dry matter in diets. Ramie is also nutritionally rich, with crude protein content around 22%, reasonable amino acid composition, high lysine content, and abundant carotenoids, vitamin B2, and calcium. Ramie exhibits high biomass yield with seven annual harvests, though nutrient composition varies among harvests. This experiment utilized the fourth cutting of ramie harvested in August, when biomass yield was high and nutrient contents approximated the annual average. Compared with alfalfa, ramie showed advantages in crude protein, ether extract, and calcium contents, but disadvantages in higher crude ash, NDF, and ADF contents.

Southern regions are rich in water and heat resources, but legume forages such as alfalfa are constrained by regional and climatic conditions, limiting their yield potential and cultivation scope, with production far from meeting the rapid development demands of the herbivorous livestock industry. Therefore, developing forage resources that can effectively replace alfalfa is of great significance. Given its similar nutritional profile to alfalfa and suitability for cultivation in southern regions, ramie has potential as an alternative feed ingredient. Maknev et al. studied the application of ramie substituting alfalfa in diets for Bulgarian Red bulls, finding that ramie-based diets did not significantly affect the proportions of meat, bone, and skin or the moisture, crude protein, and crude fat contents in meat of 6–12 month-old bulls. Hutabarat et al. reported that substituting more than 40% of elephant grass with ramie leaves or silage in total mixed rations for goats did not significantly affect growth performance. Dos Santos et al. found that substituting varying proportions of napier grass with ramie in dairy goat diets did not significantly affect daily gain or dry matter and crude protein intake. However, no studies have reported on substituting alfalfa with ramie in total mixed rations for Boer goats. The present results indicate that while ADG decreased to varying degrees after substituting different proportions of alfalfa with ramie, the reductions were only 1.93% and 6.16% in the 25% and 50% substitution groups, respectively, with no significant differences from the control group. This demonstrates that ramie can replace a portion of alfalfa as

a roughage source in goat diets.

Serum albumin and globulin contents reflect protein absorption and metabolism status, while the albumin/globulin ratio indicates animal health status. Elevated total protein and albumin levels suggest vigorous metabolic activity. This study showed that substituting different proportions of alfalfa with ramie did not significantly affect serum total protein, albumin, or globulin contents in goats, indicating no significant impact on protein absorption, metabolism, or health status. Serum uric acid and creatinine levels are indicators of kidney function. While creatinine was not significantly affected, uric acid was detected only in the serum of goats fed the diet with 100% ramie substitution, possibly due to the extremely high substitution rate and severely imbalanced calcium-to-phosphorus ratio (23:1) in ramie, which can cause kidney damage and urolithiasis in goats, particularly wethers. The specific mechanisms require further investigation. Free triiodothyronine and free thyroxine are primary thyroid hormones. Certain anti-nutritional factors in feed can damage the thyroid gland, reducing serum free triiodothyronine and free thyroxine levels, such as glucosinolates in rapeseed meal. This study found that serum free triiodothyronine content decreased significantly in goats fed diets with 50% or more ramie substitution, likely due to anti-nutritional factors in ramie that increased with substitution rate and caused thyroid damage.

Squibb et al. studied the digestibility of ramie, reporting that when harvested at heights below 50 cm, its crude protein, ether extract, and crude fiber digestibility were comparable to legume forages like alfalfa. Ridla et al. substituted 10% of concentrate with ramie or silage ramie in total mixed rations, finding that ramie improved crude fat digestibility, reduced nitrogen-free extract digestibility, but did not significantly affect crude protein, dry matter, organic matter, or crude fiber digestibility. The present results similarly showed no significant changes in apparent digestibility of dry matter, crude protein, ether extract, NDF, ADF, or total phosphorus after substituting different proportions of alfalfa with ramie. However, calcium apparent digestibility in the 100% substitution group was significantly lower than in the control group, likely because the high calcium content in ramie elevated dietary calcium levels beyond the absorption capacity of goats, resulting in reduced calcium apparent digestibility.

Conclusion

Ramie possesses relatively high nutritional value and can be efficiently utilized as a high-quality forage to partially replace alfalfa in Boer goat diets.

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