Effects of Different Energy Levels of Elephant Grass-Based Diets on Growth, Digestibility, and Serum Biochemical Parameters in Beef Cattle: Postprint

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Abstract

This experiment aimed to investigate the effects of replacing elephant grass with corn in diets to increase energy levels on growth, digestion, and serum biochemical indices of beef cattle, thereby providing a basis for the rational use of energy feed in the beef cattle fattening process. Thirty 21-month-old crossbred bulls [(449.4±45.7) kg] were selected and randomly divided into 3 groups (n=10): low-energy, medium-energy, and high-energy groups, with corn and elephant grass contents in dietary dry matter of 12.5%, 22.5%, 32.5% and 60.0%, 50.0%, 40.0%, respectively. The experimental period was 45 d, including a 5 d preliminary period and a 40 d formal experimental period. During the formal experimental period, average daily gain and feed-to-gain ratio were measured, and economic benefits were calculated; during the last 5 d, apparent dry matter digestibility was determined using the total fecal collection method; during the last 2 d, rumen fluid pH was measured before morning feeding and at 2.5 and 6.0 h after morning feeding; on the last 1 d, blood was collected for determination of serum biochemical indices. The results showed: 1) Average daily gain was highest in the high-energy group (1.31 kg/d), followed by the medium-energy group (1.21 kg/d), and lowest in the low-energy group (0.96 kg/d), but differences among groups were not significant ($P>0.05$); dry matter intake and apparent dry matter digestibility in each group were high-energy group > medium-energy group > low-energy group, with significant differences between the high-energy and low-energy groups ($P<0.05$), while the feed-to-gain ratio showed the opposite trend; 2) Rumen fluid pH before morning feeding was lowest in the high-energy group, but differences among groups were not significant ($P>0.05$); rumen fluid pH at 2.5 and 6.0 h after morning feeding in the high-energy and medium-energy groups was significantly lower than that in the low-energy group ($P<0.05$); 3)

Economic benefit was lowest in the low-energy group, with gross profit in the low-energy group being 46.10% and 40.28% lower than that in the high-energy and medium-energy groups, respectively; 4) Differences in serum biochemical indices among groups were not significant (P>0.05). In conclusion, when elephant grass was used as the sole roughage during the beef cattle fattening period, increasing dietary corn content to raise energy levels improved dry matter intake, apparent dry matter digestibility, average daily gain, and economic benefits, and reduced the feed-to-gain ratio; when dietary corn content reached 32.5%, there were also no adverse effects on rumen fermentation or beef cattle health, yielding the greatest economic returns from farming.

Full Text

Effects of Elephant Grass Diets with Different Energy Levels on Growth, Digestion, and Serum Biochemical Parameters of Beef Cattle

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Abstract: This experiment aimed to investigate the effects of increasing dietary energy level by substituting elephant grass with corn on the growth performance, digestion, and serum biochemical parameters of beef cattle, thereby providing a scientific basis for the rational use of energy feed during beef cattle fattening. Thirty crossbred bulls at approximately 21 months of age, with an initial body weight of (449.4±45.7) kg, were randomly divided into three groups (n=10): low energy, medium energy, and high energy groups. The dietary dry matter contents of corn and elephant grass were 12.5% and 60.0%, 22.5% and 50.0%, and 32.5% and 40.0%, respectively. The 45-day experimental period consisted of a 5-day preliminary period followed by a 40-day formal trial. During the formal trial, average daily gain and feed-to-gain ratio were measured and economic benefits were calculated. In the final 5 days, dry matter apparent digestibility was determined using the total fecal collection method. Rumen fluid pH was measured at 2.5 and 6.0 hours after morning feeding during the last 2 days, with a pre-feeding baseline measurement. Blood samples were collected on the final day for serum biochemical analysis. The results showed: (1) Average daily gain was highest in the high energy group (1.31 kg/d), followed by the medium energy group (1.21 kg/d), and lowest in the low energy group (0.96 kg/d), though differences among groups were not statistically significant (P>0.05). Dry matter

intake and dry matter apparent digestibility followed the same trend (high > medium > low), with significant differences between high and low energy groups ($P<0.05$), while feed-to-gain ratio showed the opposite pattern. (2) Pre-feeding rumen fluid pH was lowest in the high energy group, but inter-group differences were not significant ($P>0.05$). However, rumen fluid pH at 2.5 and 6.0 hours post-feeding was significantly lower in both high and medium energy groups compared to the low energy group ($P<0.05$). (3) Economic benefit was lowest in the low energy group, with gross profit 46.10% and 40.28% lower than the high and medium energy groups, respectively. (4) No significant differences were observed in serum biochemical parameters among groups ($P>0.05$). In conclusion, when elephant grass is used as the sole forage source during beef cattle fattening, replacing elephant grass with corn to increase dietary energy level enhances dry matter intake, dry matter apparent digestibility, average daily gain, and economic benefit while reducing feed-to-gain ratio. A corn content of 32.5% in the diet does not adversely affect rumen fermentation or animal health and yields the greatest economic returns.

Keywords: beef cattle; energy level; growth performance; serum biochemical parameters; economic benefit

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Grains are the primary energy source in beef cattle fattening diets, but either excessive or insufficient grain content can compromise fattening performance. Therefore, rational combination of energy and roughage feeds is crucial for improving beef cattle fattening outcomes [1-2]. Corn, known as the "king of feed," is the preferred energy feed for fattening beef cattle. Research has shown that appropriately increasing dietary corn content can improve weight gain and production efficiency [3-4]. Elephant grass is a major roughage source in subtropical regions, characterized by high yield and good palatability but also high crude fiber and low energy content. Studies by Huang et al. [5] and Liang et al. [6] demonstrated that feeding elephant grass to dairy cows and goats increased milk production and growth performance, respectively. He et al. [7] reported that supplementing elephant grass with rice bran and cottonseed meal produced favorable weight gain and economic returns in beef cattle, confirming elephant grass as a quality roughage for beef fattening. However, excessive elephant grass in fattening diets reduces dietary energy level and limits weight gain, while excessive corn increases feed costs and risks of acidosis and reduced fiber digestibility. Thus, optimizing the combination of elephant grass and corn to balance weight gain and feed conversion is essential for improving beef production profitability. This study investigated the effects of different energy levels in elephant grass-based diets on growth, digestion, and serum biochemical parameters of beef cattle in subtropical regions, providing reference for scientifically utilizing corn to modulate energy levels in elephant grass diets.

1.1 Experimental Design and Management

A completely randomized block design was employed. Thirty healthy Limousin × Angus × Simmental crossbred bulls at approximately 21 months of age, with body weight of (449.4±45.7) kg, were randomly allocated into three groups (n=10) and housed individually in tie-stalls. Three experimental diets were formulated by replacing elephant grass with corn at 10.0% increments (dry matter basis): low energy, medium energy, and high energy groups, with corn and elephant grass contents of 12.5% and 60.0%, 22.5% and 50.0%, and 32.5% and 40.0% (DM basis), respectively. Elephant grass contained 10.0% crude protein, 63.60% neutral detergent fiber, and 35.6% acid detergent fiber on a dry matter basis. Following deworming and health conditioning, the experiment was conducted at Guangxi Huisheng Husbandry Development Co., Ltd. from March to April 2017. The 45-day trial comprised a 5-day preliminary period and a 40-day formal experimental period.

Cattle were fed twice daily at 09:30 and 15:30. The low, medium, and high energy groups received 5.0, 6.0, and 7.1 kg/(head · d) of concentrate, respectively, and 26.7, 22.3, and 17.8 kg/(head · d) of elephant grass, respectively, as total mixed rations. Feed offered and refusals were recorded daily. Water was available ad libitum. Diet composition and nutrient levels are presented in Table 1 .

1.2.1 Growth Performance, Dry Matter Apparent Digestibility, Rumen Fluid pH, and Economic Benefit

All cattle were weighed before morning feeding at the beginning and end of the experiment. Feed intake and procurement costs were recorded throughout the trial to calculate average daily gain, feed-to-gain ratio, and economic benefit. During the last 2 days, rumen fluid was collected using a stomach tube sampler (ANSCITECH, Wuhan Kelibo Equipment Co., Ltd.) at 2.5 and 6.0 hours after morning feeding, with a pre-feeding baseline measurement. The tube was inserted 2 m into the oral cavity and rumen fluid was extracted using a vacuum pump; the first 200 mL was discarded and the subsequent 500 mL was retained as the sample [8]. Rumen fluid pH was measured immediately after collection. During the final 5 days, daily feed offered, refusals, and fecal output were recorded and sampled. Feces were collected immediately after defecation into designated buckets, weighed daily, and subsampled. Fecal samples were preserved with 10% dilute sulfuric acid and frozen. Diet, refusal, and fecal samples were analyzed for dry matter content. Dry matter apparent digestibility was calculated as: [(dry matter intake - fecal dry matter)/dry matter intake] × 100. Gross profit was estimated as income from weight gain minus total feed costs, excluding other expenses; live cattle price was 26 RMB/kg and feed costs were calculated using real-time procurement prices.

1.2.2 Serum Biochemical Parameter Determination

On the final day of the formal trial, blood samples (10 mL) were collected from the jugular vein 5 hours after morning feeding. Serum was separated by centrifugation at 3,500 r/min for 5 min. Serum samples were analyzed at Guangxi International Zhuang Medicine Hospital using an automatic biochemical analyzer. Measured parameters included total protein, albumin, globulin, urea nitrogen, total cholesterol, triglycerides, glucose, and activities of alkaline phosphatase, alanine aminotransferase, and aspartate aminotransferase.

1.3 Data Processing and Analysis

Experimental data were preliminarily processed using Excel 2003 and analyzed using SPSS 22.0 software. One-way ANOVA was performed, and Duncan' s multiple comparison test was used for inter-group significance testing, with $P<0.05$ indicating statistical significance.

2.1 Growth Performance, Dry Matter Apparent Digestibility, and Rumen Fluid pH

As shown in Table 2 , no significant differences were observed in initial or final body weight among groups ($P>0.05$). Average daily gain was highest in the high energy group and lowest in the low energy group, though differences were not statistically significant ($P>0.05$). Dry matter intake differed significantly among groups ($P<0.05$), being highest in the high energy group and lowest in the low energy group. Dry matter apparent digestibility was significantly higher in the high energy group than in the low energy group ($P<0.05$), while feed-to-gain ratio was significantly lower ($P<0.05$); however, neither parameter differed significantly between the high energy and medium energy groups ($P>0.05$). Pre-feeding rumen fluid pH was lowest in the high energy group and highest in the medium energy group, but differences were not significant ($P>0.05$). Rumen fluid pH at 2.5 and 6.0 hours post-feeding was significantly lower in the high and medium energy groups compared to the low energy group ($P<0.05$), but did not differ between the two higher-energy groups ($P>0.05$).

2.2 Economic Benefit Analysis

As shown in Table 3 , feed cost was highest in the high energy group, followed by the medium energy group, and lowest in the low energy group. Daily income and gross profit followed the same pattern. Gross profit in the low energy group was 46.10% and 40.28% lower than in the high and medium energy groups, respectively.

2.3 Serum Biochemical Parameters

As shown in Table 4 , no significant differences were observed among groups in serum total protein, albumin, globulin, urea nitrogen, triglycerides, total choles-

terol, glucose, or activities of alkaline phosphatase, alanine aminotransferase, and aspartate aminotransferase (P>0.05).

3.1 Growth Performance, Dry Matter Apparent Digestibility, and Rumen Fluid pH

High-moisture roughage in fattening diets reduces dietary energy level and dry matter intake, thereby limiting weight gain [9]. As the primary energy source in beef cattle fattening diets, corn is crucial for increasing dietary energy and intake to maintain weight gain [10-11]. However, excessive corn in concentrate increases dietary starch, risking acidosis and reduced fiber digestibility [12]; thus, appropriate corn inclusion is essential for healthy weight gain. This study demonstrated that as high-moisture, high-fiber elephant grass decreased and high-energy corn increased, both dry matter intake and average daily gain increased, consistent with Johnson et al. [13] who reported maximum dry matter intake and gain at highest concentrate levels. However, despite lower fiber and higher soluble carbohydrates, the high energy group did not differ significantly from the medium energy group in dry matter apparent digestibility, aligning with Potts et al. [14] who found digestibility unaffected by intake under high-starch conditions, possibly due to increased passage rate at higher intakes. The higher digestibility and gain in the medium and high energy groups may be attributed to higher starch and energy levels, while the low energy group' s high neutral detergent fiber content reduced digestibility. Notably, the low energy group' s dry matter intake was only 6.55% and 9.80% lower than the medium and high energy groups, respectively, and digestibility was 11.48% and 15.63% lower, yet average daily gain decreased substantially by 20.66% and 26.72%. This indicates that high elephant grass content negatively impacts weight gain through reduced intake, digestibility, and energy consumption. Furthermore, concentrate fermentation produces primarily propionate with minimal methane energy loss, whereas roughage fermentation yields more acetate with greater methane loss, and propionate metabolism has lower heat increment than acetate [15], making high-energy feeding more efficient for weight gain.

Rumen fluid pH in all groups decreased at 2.5 hours post-feeding and recovered by 6.0 hours, consistent with normal rumen fermentation patterns [16]. The high and medium energy groups had lower pre- and post-feeding pH than the low energy group, also consistent with normal patterns [17]. However, all groups maintained pH above 6.7, with no risk of rumen acidosis (pH <6.0) [18], indicating that even at a concentrate-to-roughage ratio of 6:4 and starch content of 29.1%, using elephant grass as the sole roughage did not adversely affect rumen fermentation or fiber digestion, and provided adequate effective fiber for rumination and microbial fermentation when elephant grass comprised 40.0% of the diet.

3.2 Feed Conversion and Economic Benefit Analysis

Economic benefit in beef production depends on feed-to-gain ratio, which relates to diet composition and balance. The high energy group had the lowest feed-to-gain ratio, followed by the medium energy group, with the low energy group highest, confirming that corn substitution for elephant grass improved feed conversion efficiency. Although feed costs were highest for the high energy group, daily income and gross profit followed the same trend, demonstrating a positive relationship between feed investment and profitability. The low energy group' s average daily gain was 20.66% and 26.72% lower than the medium and high energy groups, respectively, while gross profit was 46.10% and 40.28% lower, confirming that low-energy feeding most severely impacts economic returns during fattening, consistent with Zhang et al. [19].

3.3 Serum Biochemical Parameters

Serum biochemical parameters reflect nutrient metabolism, internal homeostasis, and overall health [20]. No significant differences were observed among groups in parameters related to carbohydrate and lipid metabolism (total protein, albumin, globulin, urea nitrogen, triglycerides, total cholesterol, glucose) or enzyme activities (alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase), indicating that high-energy elephant grass diets did not adversely affect liver, heart, skeletal development, or lipid metabolism. Yan et al. [21] similarly reported that high concentrate-to-roughage ratios do not harm finishing cattle health when effective fiber is adequate.

4 Conclusion

When elephant grass is used as the sole forage during mid-stage beef cattle fattening, replacing elephant grass with corn to increase dietary energy level enhances dry matter intake, dry matter apparent digestibility, and average daily gain while reducing feed-to-gain ratio, despite increasing feed costs. This approach does not adversely affect rumen fermentation or animal health, even at a corn content of 32.5%, and substantially improves economic returns. A dietary corn content of 32.5% yields the fastest weight gain and optimal economic benefit.

References

[1] CHEN H. Comparative study on composition differences and rumen degradation characteristics of different energy feeds[D]. Master' s thesis. Ya' an: Sichuan Agricultural University, 2013.
[2] DRENNAN M J, KEANE M G. Responses to supplementary concentrates for finishing steers fed silage[J]. Irish Journal of Agricultural Research, 1987, 26(2/3): 115-127.
[3] XIE G Q, HE Y Y, CHENG S F, et al. Study on feeding effects of several tropical forages on beef cattle[J]. Chinese Journal of Grassland, 2006(1): 51-53.

[4] DAI Z H, GAN X H, XU G H, et al. Observation on fattening effect of Gui Mu No. 1 elephant grass silage on beef cattle[J]. Jiangxi Journal of Animal Husbandry and Veterinary Medicine, 2014(1): 40-41.
[5] HUANG X, WEN X W, WU L, et al. Experiment on effect of Gui Mu No. 1 hybrid elephant grass on production performance of dairy cows[J]. Guangdong Journal of Animal and Veterinary Science, 2009(5): 27-28.
[6] LIANG Y C, TENG S H. Study on feeding goats with three forages including Gui Mu No. 1[J]. Pratacultural Science, 2000(3): 51-52.
[7] HE Y Y, XIE G Q, SHI Q H, et al. Effects of dwarf elephant grass supplemented with different proportions of rice bran and cottonseed meal on performance and economic benefits of growing-finishing cattle[J]. Pratacultural Science, 2006(4): 59-62.
[8] SHEN J S, CAI Z, SONG L J, et al. Insertion depth of oral stomach tubes affect the fermentation parameters of ruminal fluid collected in dairy cows[J]. Journal of Dairy Science, 2012, 95: 5978-5984.
[9] ZHANG B H, SU Z, HU X F, et al. Effects of roughage quality on ruminant production performance[J]. Feed Research, 2011(9): 60-62.
[10] LI F C, FENG Y L, MO F, et al. Effects of abomasal infusion of cooked corn on nutrient digestibility, energy utilization and blood glucose concentration in beef cattle fed single Leymus chinensis diet[J]. Chinese Journal of Animal Nutrition, 2001, 13(2): 38-42.
[11] TANG L B. Effects of dietary concentrate-to-roughage ratio on ruminants[J]. Jiangxi Journal of Animal Husbandry and Veterinary Medicine, 2017(1): 37-38.
[12] HUA J L, GUO L, WANG L K, et al. Effects of different concentrate-to-roughage ratios on rumen volatile fatty acids in Huang-Huai White goats[J]. Journal of Northeast Agricultural University, 2013, 44(6): 58-62.
[13] JOHNSON R J, KARUNAJEEWA H. The effects of dietary minerals and electrolytes on the growth and physiology of the young chick[J]. The Journal of Nutrition, 1985, 115(12): 1680.
[14] POTTS S B, BOERMAN J P, LOCK A L, et al. Relationship between residual feed intake and digestibility for lactating Holstein cows fed high and low starch diets[J]. Journal of Dairy Science, 2017, 100(1): 265.
[15] LI W Z, SHAN A S. Functions of volatile fatty acids in animals[J]. Feed Review, 2003(10): 5-7.
[16] WANG S P, WANG W J, WANG J Q, et al. Effects of dietary concentrate-to-roughage ratio on rumen fermentation and lactation performance of dairy cows[J]. Journal of Northwest A&F University (Natural Science Edition), 2007, (6): 44-50.
[17] TAN Z L, LU D X, HU M, et al. Effects of different carbohydrate ratios in sheep diets on rumen environment parameters[J]. Chinese Journal of Animal Nutrition, 2000, 12(1): 42-47.
[18] HOUTERT M F J V. The production and metabolism of volatile fatty acids by ruminants fed roughages: a review[J]. Animal Feed Science & Technology, 1993, 43(3/4): 189-225.
[19] ZHANG G L, WANG C Y. Effects of nutrition level on fattening of different crossbred beef cattle[J]. Feed Research, 2007(2): 48-52.

[20] SUDRE K, CASSAR-MALEK I, LISTRAT A, et al. Biochemical and transcriptomic analyses of two bovine skeletal muscles in Charolais bulls divergently selected for muscle growth[J]. Meat Science, 2005, 70(2): 267-277.
[21] YAN W P, ZHANG Y Y, WANG C, et al. Effects of different concentrate-to-roughage ratios on performance and blood parameters of beef cattle[J]. Feed Research, 2014, (21): 54-57.

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