Effects of Silage-Combined Total Mixed Ration on Growth Performance and Blood Parameters of Fattening Beef Cattle: Postprint

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Abstract

This study aimed to investigate the effects of silage-combination total mixed ration on growth performance and blood parameters in finishing beef cattle. Thirty Simmental bulls with good body condition and similar body weight [(440.5±3.5) kg] were randomly allocated into 2 groups, with 15 cattle per group. The control group (Group C) was fed a single silage-type total mixed ration, while the treatment group (Group T) was fed a silage-combination total mixed ration. The experimental period lasted 180 days. The results showed that: 1) During days 1-60, 61-120, and 121-180, the average daily feed intake of Group T was significantly lower than that of Group C (P 0.05), while the average daily gain of Group T was higher than that of Group C (P > 0.05); during days 61-120 and 121-180, the feed conversion ratio of Group T was significantly lower than that of Group C (P<0.05). 2) On days 120 and 180, the blood red blood cell count (RBC) and hemoglobin concentration (HGB) of Group C were significantly higher than those of Group T (P 0.05); on day 180, the hematocrit (HCT) and red cell distribution width-standard deviation (RDW-SD) of Group C were significantly higher than those of Group T (P<0.05). 3) There were no significant differences in plasma antioxidant indices between the two groups (P>0.05). 4) On days 60 and 120, the plasma urea nitrogen (UN) content of Group C was significantly lower than that of Group T (P<0.05); on day 60, the plasma total cholesterol (T-CHO) content of Group C was significantly lower than that of Group T (P<0.05); on days 120 and 180, the plasma aspartate aminotransferase (AST) activity of Group C was significantly higher than that of Group T (P 0.05); on day 180, the plasma alanine aminotransferase (ALT) activity of Group C was significantly higher than that of Group T (P<0.05). In conclusion, the silage-combination total mixed ration had no adverse effects on the antioxidant function and health status of finishing beef cattle, and could improve body metabolism to a certain extent, as well as enhance the growth performance of finishing beef cattle.

Full Text

Effects of Silage Combination Type Total Mixed Ration on Growth Performance and Blood Parameters of Fattening Beef Cattle

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Abstract: This study aimed to investigate the effects of silage combination type total mixed ration on growth performance and blood parameters of fattening beef cattle. Thirty Simmental bulls with good body condition and similar initial body weight [(440.5±3.5) kg] were selected and randomly divided into two groups of fifteen cattle each. The control group (C group) was fed a single silage type total mixed ration, while the test group (T group) received a silage combination type total mixed ration. The trial lasted for 180 days. The results showed: 1) During days 1-60, 61-120, and 121-180, the average daily feed intake of T group was significantly lower than that of C group (P 0.05), while the average daily gain of T group was higher than that of C group (P > 0.05). During days 61-120 and 121-180, the feed to gain ratio of T group was significantly lower than that of C group (P<0.05). 2) On days 120 and 180, the red blood cell count (RBC) and hemoglobin concentration (HGB) in blood of C group were significantly higher than those of T group (P 0.05). On day 180, the hematocrit (HCT) and standard deviation of red blood cell distribution width (RDW-SD) in blood of C group were significantly higher than those of T group (P<0.05). 3) No significant differences were observed in plasma antioxidant parameters between the two groups (P>0.05). 4) On days 60 and 120, the plasma urea nitrogen (UN) content of C group was significantly lower than that of T group (P<0.05). On day 60, the plasma total cholesterol (T-CHO) content of C group was significantly lower than that of T group (P<0.05). On days 120 and 180, the plasma glutamic-oxalacetic transaminase (AST) activity of C group was significantly higher than that of T group (P 0.05). On day 180, the plasma glutamic pyruvic transaminase (ALT) activity of C group was significantly higher than that of T group (P<0.05). In conclusion, the silage combination type total mixed ration had no adverse effects on the antioxidant function and health status of fattening beef cattle, while it could improve body metabolism to a certain extent and enhance the growth performance of beef cattle.

Keywords: silage; total mixed ration; beef cattle; growth performance; blood parameters

1.1 Experimental Materials

The wrapped silage feeds used in the experiment—corn silage, alfalfa silage, and oat silage—were purchased from Gansu Minxiang Forage Co., Ltd. Alfalfa hay, wheat straw, and concentrate (corn, soybean meal, cottonseed meal, linseed cake, wheat bran, and premix, etc.) as well as corn silage (trench silage) were provided by Dingxi Jiatiangxia Beef Cattle Breeding Company.

1.2 Experimental Design

The experimental diets were formulated according to the NRC (2007) nutrient requirements for beef cattle with an expected daily gain of 1.2 kg. The composition and nutrient levels of the experimental diets are shown in Table 1 . Thirty Simmental bulls with good body condition and similar body weight [(440.5±3.5) kg] were selected and randomly divided into two groups (fifteen cattle per group) according to the principle of random grouping. The control group (C group) was fed a single silage type total mixed ration (corn silage-concentrate type total mixed ration, designed by the beef cattle farm), while the test group (T group) received a silage combination type total mixed ration (corn silage, alfalfa silage, and oat silage combination type total mixed ration, designed by this experiment). The trial lasted for 180 days and was divided into three stages: early stage (days 1-60), middle stage (days 61-120), and late stage (days 121-180).

Table 1 Composition and nutrient levels of experimental diets (DM basis) %

Items	Groups	Day 1 to 60	Day 61 to 120	Day 121 to 180
Ingredients				
Corn silage[1])	C	45.00	48.00	50.00
	T	15.00	16.00	17.00
Oats silage	T	15.00	16.00	17.00
Alfalfa silage	T	15.00	16.00	17.00
Alfalfa hay	C	10.00	8.00	6.00
Wheat straw	C	5.00	4.00	3.00
Corn	C/T	13.50	13.00	12.50
Wheat bran	C/T	3.00	2.50	2.00
Soybean meal	C/T	4.00	3.50	3.00
Cottonseed	C/T	3.00	2.50	2.00
Linseed	C/T	2.00	1.50	1.00
NaHCO	C/T	0.50	0.50	0.50
CaHPO	C/T	0.30	0.30	0.30
NaCl	C/T	0.30	0.30	0.30
Premix[2])	C/T	0.40	0.40	0.40
Total		100.00	100.00	100.00

Items	Groups	Day 1 to 60	Day 61 to 120	Day 121 to 180
Nutrient level[3])				
Metabolizable energy (MJ/kg)		13.34	13.34	13.34
Crude protein		13.50	12.97	12.45
Neutral detergent fiber		38.50	37.50	36.50
Acid detergent fiber		22.50	21.50	20.50

[1]) C group: trench-style corn silage; T group: wrapped corn silage.
[2]) Premix provided the following per kg of diets: VA 160,000 IU, VD 50,000 IU, VE 900 IU, VB 120 mg, nicotinic acid 500 mg, Fe 1,200 mg, Cu 150 mg, Zn 1,000 mg, Mn 500 mg.
[3]) Nutrient levels were calculated values [21].

1.3 Feeding Management

During the trial period, beef cattle were individually housed in tie-stalls, with pens kept clean and dry and regularly disinfected. The experimental diets were mixed using a total mixed ration mixer and fed twice daily (at 07:00 and 17:00). Feed allowance was adjusted to maintain 5%–10% refusals, and cattle had free access to water after feeding. Regular deworming and disinfection of the experimental cattle and barns were conducted during the trial period.

1.4.1 Growth Performance Indicators

Average Daily Gain (ADG): Cattle were weighed at the start of the experiment and on days 60, 120, and 180 to calculate the average daily gain for each group. **Average Daily Feed Intake (ADFI):** During the trial period, refusals were accurately recorded daily at 07:00 to calculate the average daily feed intake. **Feed to Gain Ratio (F/G):** The ratio of average daily feed intake to average daily gain was calculated as the feed to gain ratio.

1.4.2 Blood Parameters

From each group, seven cattle with similar body condition were selected for blood sampling via jugular venipuncture before morning feeding on days 60, 120, and 180. Blood samples were collected using anticoagulant tubes [containing dipotassium ethylenediaminetetraacetate (EDTA-K)] and heparin sodium tubes produced by Jiangsu Kangjian Medical Supplies Co., Ltd. Blood in anticoagulant tubes was immediately inverted 4–5 times to ensure thorough mixing with the anticoagulant to prevent clotting, stored at room temperature, and analyzed for routine blood parameters within 4 hours. Blood in heparin sodium tubes was centrifuged at 3,500 r/min for 10 minutes immediately after collection to separate plasma, which was stored at -20 °C for later analysis.

A fully automatic blood analyzer (Mindray BC-3000plus) was used to detect white blood cell count (WBC), hemoglobin concentration (HGB), red blood

cell count (RBC), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), coefficient of variation of red blood cell distribution width (RDW-CV), standard deviation of red blood cell distribution width (RDW-SD), and platelet count (PLT). Plasma total protein (TP), albumin (ALB), urea nitrogen (UN), total cholesterol (T-CHO), -hydroxybutyrate (-HB), and creatinine (CR) contents, as well as activities of glutamic-oxalacetic transaminase (GOT), glutamic pyruvic transaminase (GPT), alkaline phosphatase (AKP), superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), total antioxidant capacity (T-AOC), and malondialdehyde (MDA) content were all measured using assay kits provided by Beijing Huaying Biotechnology Research Institute, strictly following the kit instructions.

1.5 Statistical Analysis

Data were initially processed using Excel 2010, and variance analysis was performed using SPSS 19.0 statistical software. Multiple comparisons between groups were conducted using the LSD method. Results are expressed as mean ± standard error, with P 0.05 as the criterion for significant difference.

2.1 Effects of Silage Combination Type Total Mixed Ration on Growth Performance of Beef Cattle

As shown in Table 2 , during the early, middle, and late stages of the experiment, the average daily feed intake of T group was significantly lower than that of C group (P 0.05), while the average daily gain of T group was higher than that of C group (P > 0.05). During the middle and late stages, the feed to gain ratio of T group was significantly lower than that of C group (P<0.05). From the perspective of experimental stages, both groups showed the highest average daily feed intake and feed to gain ratio during the late stage, which was significantly higher than that in the early stage (P<0.05).

Table 2 Effects of silage combination type total mixed ration on growth performance of beef cattle

Items	Period	Group C	Group T	P-value
Average daily feed intake (ADFI, kg/d)	Day 1-60	12.78±0.22	11.38±0.11	<0.01
	Day 61-120	16.48±0.05	12.97±0.09	<0.01
	Day 121-180	16.80±0.09	13.50±0.06	<0.01

Items	Period	Group C	Group T	P-value
Average daily gain (ADG, kg/d)	Day 1-60	1.30±0.09	1.56±0.11	>0.05
	Day 61-120	1.10±0.10	1.15±0.06	>0.05
	Day 121-180	1.10±0.09	1.12±0.06	>0.05
Feed to gain ratio (F/G)	Day 1-60	9.83±1.12	7.29±1.01	<0.01
	Day 61-120	14.98±2.01	11.27±1.14	<0.01
	Day 121-180	15.27±1.34	12.05±1.34	<0.01

P 0.05 indicates significant difference between groups in the same row. Values with different small letter superscripts within the same column for the same index indicate significant difference (P<0.05). The same applies below.

2.2 Effects of Silage Combination Type Total Mixed Ration on Blood Routine Parameters of Beef Cattle

As shown in Table 3 , on days 120 and 180, the blood RBC and HGB of C group were significantly higher than those of T group (P 0.05). On day 180, the blood HCT and RDW-SD of C group were significantly higher than those of T group (P<0.05). No significant differences were observed in other blood routine parameters between the two groups (P>0.05). From the perspective of experimental stages, the blood RBC and HGB of T group on day 120 were significantly lower than those on days 60 and 180 (P<0.05), with the highest values observed on day 180. The blood HGB and MCH of C group on day 180 were significantly higher than those on days 60 and 120 (P<0.05). The blood MCH of T group on day 180 was significantly higher than that on day 120 (P<0.05). The blood HCT and MCV of C group on day 180 were significantly higher than those on days 60 and 120 (P<0.05). The blood MCHC, RDW-CV, and RDW-SD of C group were lowest on day 120 and significantly lower than those on days 60 and 180 (P<0.05). The blood MCHC and RDW-CV of T group were lowest on day 120 and significantly lower than those on days 60 and 180 (P<0.05).

Table 3 Effects of silage combination type total mixed ration on blood routine parameters of beef cattle

Items	Day 60	Day 120	Day 180	P-value
White blood cell count (WBC, $\times 10\ L^{1}$)	C: 9.38±0.41	C: 9.12±0.47	C: 9.60±0.46	>0.05
	T: 8.89±0.38	T: 8.33±0.42	T: 8.20±0.42	
Red blood cell count (RBC, $\times 10^{12}$ L^{1})	C: 8.44±0.36	C: 8.59±0.33	C: 9.11±0.18	<0.01
	T: 8.38±0.25	T: 7.64±0.19	T: 8.42±0.18	
Hemoglobin concentration (HGB, g/L)	C: 135.17±3.59	C: 128.71±3.30	C: 125.71±4.69	<0.01
	T: 113.57±2.89	T: 149.67±2.93	T: 135.00±3.80	
Hematocrit (HCT, %)	C: 36.90±1.53	C: 36.24±1.03	C: 38.01±1.70	<0.01
	T: 34.91±1.06	T: 42.63±1.26	T: 37.67±1.40	
Mean corpuscular volume (MCV, fL)	C: 44.77±0.80	C: 43.37±0.99	C: 44.31±0.55	<0.01
	T: 45.77±0.72	T: 46.78±0.49	T: 44.81±1.68	
Mean corpuscular hemoglobin (MCH, pg)	C: 15.59±0.20	C: 15.41±0.23	C: 14.60±0.13	<0.01
	T: 16.45±0.11	T: 16.04±0.42	T: 14.81±0.15	

Items	Day 60	Day 120	Day 180	P-value
Mean corpuscular hemoglobin concentration (MCHC, g/L)	C: 356.29±2.71	C: 355.86±4.11	C: 330.57±3.06	<0.01
	T: 351.83±4.26	T: 358.86±4.28	T: 325.29±4.96	
RDW-CV (%)	C: 20.03±0.65	C: 18.96±0.34	C: 16.56±0.21	<0.01
	T: 21.35±0.62	T: 20.26±0.47	T: 17.26±0.30	
RDW-SD (fL)	C: 30.09±1.45	C: 28.14±0.67	C: 25.73±0.60	<0.01
	T: 34.03±0.79	T: 30.97±0.86	T: 27.31±0.84	
Platelet count (PLT, $\times 10\ L^{1}$)	C: 381.57±30.93	C: 335.71±26.99	C: 335.86±21.65	>0.05
	T: 321.71±21.69	T: 310.50±33.40	T: 320.14±29.81	

2.3 Effects of Silage Combination Type Total Mixed Ration on Plasma Antioxidant Parameters of Beef Cattle

As shown in Table 4 , no significant differences were observed in plasma antioxidant parameters between the two groups (P>0.05). From the perspective of experimental stages, the plasma T-AOC and SOD activity of both groups were highest on day 180. The plasma T-AOC of C group on day 180 was significantly higher than that on day 120 (P<0.05), and the plasma SOD activity of C group on day 180 was significantly higher than that on days 60 and 120 (P<0.05). The plasma MDA content of both groups was lowest on day 180. The plasma GSH-Px activity of C group was highest on day 180, while that of T group was highest on day 120.

Table 4 Effects of silage combination type total mixed ration on plasma antioxidant parameters of beef cattle

Items	Day 60	Day 120	Day 180	P-value
Total antioxidant capacity (T-AOC, U/mL)	C: 9.28±0.62	C: 8.25±0.85	C: 8.39±0.53	>0.05
	T: 8.51±0.73	T: 10.88±0.75	T: 10.17±1.10	
Glutathione peroxidase (GSH-Px, U/mL)	C: 762.46±47.43	C: 794.97±72.69	C: 912.14±80.05	>0.05
	T: 877.61±89.91	T: 1,023.91±105.97	T: 850.66±106.89	
Superoxide dismutase (SOD, U/mL)	C: 70.38±3.96	C: 79.99±10.87	C: 81.06±6.74	<0.05
	T: 76.46±8.09	T: 109.23±11.51	T: 101.93±14.22	
Malondialdehyde (MDA, nmol/mL)	C: 3.64±0.45	C: 3.80±0.65	C: 3.30±0.50	>0.05
	T: 3.51±0.47	T: 3.03±0.40	T: 3.46±0.58	

2.4 Effects of Silage Combination Type Total Mixed Ration on Plasma Biochemical Parameters of Beef Cattle

As shown in Table 5 , on days 60 and 120, the plasma UN content of C group was significantly lower than that of T group (P<0.05). On day 60, the plasma T-CHO content of C group was significantly lower than that of T group (P<0.05). On days 120 and 180, the plasma AST activity of C group was significantly higher than that of T group (P 0.05). On day 180, the plasma ALT activity of C group was significantly higher than that of T group (P<0.05). No significant differences were observed in other plasma biochemical parameters between the two groups (P>0.05).

From the perspective of experimental stages, the plasma TP content of T group on day 180 was significantly higher than that on day 60 (P<0.05). The plasma ALB content of C group on day 180 was significantly higher than that on day 60 (P<0.05). The plasma UN content of C group on day 180 was significantly higher than that on days 60 and 120 (P<0.05), while that of T group on day 180

was significantly higher than that on day 120 (P<0.05). The plasma T-CHO content of C group on day 180 was significantly higher than that on days 60 and 120 (P<0.05), while that of T group on days 60 and 180 was significantly higher than that on day 120 (P<0.05). The plasma CR content of C group on days 120 and 180 was significantly higher than that on day 60 (P<0.05). The plasma ALT activity of C group on day 180 was significantly higher than that on days 60 and 120 (P<0.05).

Table 5 Effects of silage combination type total mixed ration on plasma biochemical parameters of beef cattle

Items	Day 60	Day 120	Day 180	P-value
Total protein (TP, g/L)	C: 74.55±3.09	C: 69.91±1.46	C: 78.74±2.04	<0.05
	T: 73.12±2.00	T: 78.90±1.89	T: 76.13±1.61	
Albumin (ALB, g/L)	C: 27.54±1.05	C: 29.12±0.81	C: 28.75±0.64	<0.05
	T: 29.03±0.68	T: 31.43±1.20	T: 30.81±0.90	
Urea nitrogen (UN, mmol/L)	C: 2.71±0.18	C: 3.30±0.15	C: 3.60±0.12	<0.01
	T: 3.14±0.12	T: 4.35±0.19	T: 3.84±0.31	
Total cholesterol (T-CHO, mmol/L)	C: 2.63±0.16	C: 3.34±0.17	C: 2.66±0.15	<0.01
	T: 2.64±0.11	T: 3.27±0.23	T: 3.33±0.13	
-hydroxybutyrate (-HB, mmol/L)	C: 0.16±0.02	C: 0.18±0.02	C: 0.16±0.02	>0.05
	T: 0.14±0.01	T: 0.12±0.01	T: 0.16±0.01	
Creatinine (CR, mol/L)	C: 99.45±3.98	C: 107.34±4.81	C: 115.53±5.08	<0.01
	T: 117.11±2.70	T: 118.80±2.91	T: 114.17±3.71	

Items	Day 60	Day 120	Day 180	P-value
Aspartate amino-trans-ferase (AST, U/L)	C: 53.42±6.12	C: 44.94±3.08	C: 54.43±2.44	<0.05
	T: 44.50±1.28	T: 62.82±6.80	T: 46.79±1.99	
Alanine amino-trans-ferase (ALT, U/L)	C: 21.17±1.79	C: 22.26±0.72	C: 27.05±1.02	<0.05
	T: 19.61±2.22	T: 21.74±2.38	T: 22.41±1.14	
Alkaline phos-phatase (ALP, U/L)	C: 109.02±17.26	C: 104.19±58.82	C: 115.82±9.49	>0.05
	T: 126.38±31.36	T: 174.23±41.92	T: 158.66±30.65	

3.1 Effects of Silage Combination Type Total Mixed Ration on Growth Performance of Beef Cattle

Reducing the feed to gain ratio and increasing average daily gain are important objectives in animal feeding trials and are of great significance for improving cattle production efficiency. This study demonstrated that the silage combination type total mixed ration could increase the average daily gain of beef cattle, promote rapid growth, significantly reduce the feed to gain ratio, and improve feed conversion efficiency. The underlying mechanism may be related to rumen fermentation patterns, specifically the content of total volatile fatty acids and the proportion of various acids.

3.2 Effects of Silage Combination Type Total Mixed Ration on Blood Routine Parameters of Beef Cattle

All blood routine parameters in this study were within normal reference ranges [23]. White blood cells are a general term for immune cells, including monocytes, neutrophils, eosinophils, and lymphocytes, which directly reflect animal

immune capacity [24] and are important formed elements in blood that eliminate pathogenic microorganisms, playing a crucial role in maintaining normal blood circulation and disease diagnosis. The results showed no significant difference in blood WBC between the two groups, indicating that the diet type under these experimental conditions had no significant effect on the immune function of beef cattle.

Blood RBC, HGB, and HCT can reflect the ability of animal blood to transport oxygen (O) and carbon dioxide (CO) [25]. Jiang et al. [26] found that animals living at high altitudes not only have more blood RBC but also smaller blood MCV, which can increase contact with oxygen in the lungs and enhance adaptation to high-altitude hypoxia, indicating that altitude significantly affects blood RBC and related parameters. Increased RBC and hemoglobin counts are mostly relative increases, such as those caused by body dehydration, which leads to blood concentration and a relative increase in RBC and hemoglobin counts [27]. The results of this study showed that the blood RBC and HGB of T group were lower than those of C group during the middle and late stages, indicating that T group was less likely to cause blood concentration. Zhang et al. [28] reported that blood RBC and HGB of beef cattle raised at the same altitude were not significantly affected by diet, and that beef cattle with similar body weight raised at the same altitude had the same O transport capacity, which is inconsistent with our results. The discrepancy may be due to different diet types affecting the redox capacity of animal bodies, thereby influencing O transport capacity.

Blood MCH, MCHC, RDW, and MCV reflect the pigment content, pigment saturation, variation degree, and volume size of red blood cells, respectively. Blood MCH, MCHC, and MCV are collectively known as the three anemia indicators. Lower blood MCH, MCHC, and MCV along with higher RDW are typically used as diagnostic criteria for iron deficiency anemia [29]. The results of this study indicated that diet effects were unlikely to cause anemia symptoms in beef cattle.

Platelets are one of the important formed elements in mammalian blood, and their number and function are closely related to the blood coagulation system, playing an important role in maintaining normal blood circulation. Throughout the experimental period, C group had higher blood PLT than T group, which may be caused by diet effects, and the underlying mechanism requires further investigation.

3.3 Effects of Silage Combination Type Total Mixed Ration on Plasma Antioxidant Parameters of Beef Cattle

Blood circulates continuously in the body, and its metabolic indicator levels can objectively reflect metabolic status and physiological function. In experiments, increased plasma T-AOC and SOD, GSH-Px activities and/or decreased MDA content are often used to indicate enhanced antioxidant capacity, and vice versa.

T-AOC is a comprehensive indicator reflecting the antioxidant capacity of the body, representing the combined effect of enzymatic and non-enzymatic systems [30]. Under normal conditions, the production, utilization, and clearance of free radicals in animal bodies are in a dynamic equilibrium state [31]. The body can utilize enzymes such as GSH-Px and SOD to scavenge free radicals. Studies have shown that if oxygen free radical content is too high and exceeds the body's scavenging capacity, it can easily lead to oxidative stress [32]. In this experiment, no significant differences were observed in plasma GSH-Px and SOD activities between the two groups. MDA is one of the most important end products of membrane lipid peroxidation, causing cross-linking and polymerization of macromolecules such as proteins and nucleic acids. Its content can reflect the degree of lipid peroxidation in tissue cells [33], and increased plasma MDA content is a marker of oxidative stress [34] that can indirectly reflect the degree of cell damage. In this study, no significant differences were observed in plasma MDA content between the two groups. These results indicate that replacing single silage type diet with silage combination type diet did not affect plasma SOD, GSH-Px activities, or MDA content in beef cattle, and therefore did not affect the antioxidant capacity of beef cattle. Furthermore, with the extension of the experimental period, plasma T-AOC and SOD activity increased while plasma MDA content decreased, indicating that the antioxidant system of beef cattle became more robust with age.

3.4 Effects of Silage Combination Type Total Mixed Ration on Plasma Biochemical Parameters of Beef Cattle

Changes in plasma biochemical parameters reflect alterations in tissue cell permeability and body metabolic function. Blood is an important component of the internal environment, transporting metabolic raw materials and waste products in the body. Changes in its composition can reflect animal growth and development, which is based on the complex biochemical processes of substance metabolism and energy conversion. The metabolic level and conversion efficiency have an inevitable connection with feed nutrient utilization efficiency and growth rate [35]. Therefore, detecting plasma biochemical parameters can reflect the physiological, nutritional, and metabolic status of experimental cattle.

Plasma TP and ALB contents can reflect protein absorption, synthesis, and catabolism in the body, as well as immune status [36]. In this study, plasma TP and ALB contents in both groups showed an increasing trend over time, possibly because growth of beef cattle promoted protein digestion and absorption to a certain extent.

Urea nitrogen is mainly produced in the liver and is the main end product of protein metabolism in the body, constituting the vast majority of non-protein nitrogen in blood. It is one of the indicators reflecting dietary protein utilization efficiency. Plasma UN content is related to the total amount of nitrogen-containing substances in the diet and protein utilization efficiency. When

nitrogen-containing substances in the diet increase or protein utilization efficiency decreases, plasma UN content can increase. Decreased plasma UN content can provide sufficient raw materials such as amino acids for protein deposition in other parts [37]. Plasma UN content is mainly affected by factors such as rumen fermentation capacity, dietary amino acid composition, liver and kidney function, total amount of fermentable carbohydrates in the rumen, and protein intake [38,39]. In this study, plasma UN content in T group was lower than that in C group during the middle and late stages, possibly because although C group had higher crude protein content, its protein utilization efficiency was lower.

Plasma T-CHO content is closely related to body lipid metabolism [33]. The liver is the main organ for cholesterol synthesis and storage, and plasma T-CHO content can reflect liver health status to a certain extent. Plasma T-CHO content reflects body lipid metabolism status. If liver cell function is damaged, blood cholesterol content will increase, forming so-called "hyperlipidemia" [40]. Additionally, cholesterol is an important component of cell membranes and plasma lipoproteins, existing in all tissues of the body and being an indispensable lipid substance in animals. However, excessively high cholesterol content can cause arteriosclerosis, which is detrimental to health. Under the conditions of this experiment, plasma T-CHO content in each group was higher at the end than at the beginning, possibly because animals have different fat metabolism mechanisms at different physiological stages, leading to changes in plasma T-CHO content.

-HB is the main component of ketone bodies and is usually used as an indicator for diagnosing ketosis. Li et al. [41] clinically confirmed that plasma -HB content was 1.2 mmol/L during subclinical ketosis. In this experiment, plasma -HB content was within the normal range, indicating that feeding silage combination type total mixed ration to experimental animals had no risk of ketosis.

Blood CR is a product of muscle metabolism in animals, and its content in blood and urine is relatively constant. The level of blood CR mainly depends on how much CR is excreted by the kidneys. Under the conditions of this experiment, plasma CR content in each group was within the normal range, and no significant effects were observed, which is consistent with existing research reports [42]. With the extension of the experimental period, plasma CR content in C group increased, while that in T group first increased and then decreased, indicating that long-term feeding of silage combination type total mixed ration was more beneficial for kidney health in beef cattle.

Plasma AST and ALT activities are important indicators for evaluating liver damage [43]. When liver function is damaged, blood transaminase activity increases. Under healthy conditions, dietary nutritional levels do not cause changes in transaminase activity. Under the conditions of this experiment, plasma AST content in C group during the late stage was significantly higher than that in T group, indicating that long-term feeding of silage combination type total mixed ration was more beneficial for liver health in beef cattle.

ALP is widely distributed in various organs of the body and is an enzyme that can dephosphorylate corresponding substrates. It is one of the most commonly used marker enzymes in immunodiagnostic reagent products. Studies have found that when animals are subjected to external stress, tissue cell damage can occur, causing tissue ALP to enter the blood and increase plasma ALP activity [44]. In normal plasma, ALP mainly comes from bones, produced by bone cells and excreted through the hepatobiliary system. Blood calcium metabolism is closely related to ALP; decreased blood calcium content indicates increased ALP activity. Throughout the experimental period, plasma ALP activity in T group was generally higher than that in C group, indicating that silage combination type total mixed ration was more sensitive to bone calcium and phosphorus metabolism.

4 Conclusion

The silage combination type total mixed ration had no adverse effects on the antioxidant function and health status of fattening beef cattle, while it could improve body metabolism to a certain extent and enhance the growth performance of beef cattle.

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